THE JOURNAL OF
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May, 1955 Vol. 45, No. 9

Contents for May

Do You Know 667
Evaluating Good Teaching ..... *R. D. Stout* 669
Publication as a Motivation for Advanced Students ..... *J. S. McNown* 672
Effect of Graduate Program on the Teacher ..... *P. F. Chenea* 675
Nuclear Education for Engineers ..... *A. M. Anderson* 678
Objective Testing in Mechanics ..... *C. J. Pratt* 683
YET-itudes—"Industrialitis" 687
ECAC Conference on International Relations 689
A Professional General Curriculum in Power ..... *J. A. M. Lyon* 700
Educational Requirements for Design and Development Engineers ..... *W. E. Bradley* 704
Evaluation of Engineering Teaching Ability ..... *T. H. Evans* 708
What is Wrong with Surveying? ..... *M. V. Smirnoff* 713
Mechanics Conference Report 717
Report of Conference on Electricity and Magnetism 721
Physics in Engineering Education 727
Purdue Conference on Thermodynamics 728
Thermodynamics Conference—Penn State 726
T-Square Page—
Teaching Engineering Graphics Effectively ..... *F. A. Heacock* 730
Candid Comments ..... *R. B. Davis* 736
Minutes of the Executive Board Meeting 741

College Notes—703 In the News—707
Section Meetings—729

The American Society for Engineering Education

A concise but thorough presentation of the fundamental information which underlies advanced electrical engineering subjects

BASIC THEORY IN ELECTRICAL ENGINEERING

by Royce G. Kloeffler and Earl L. Sitz

An introduction to the field of electrical engineering, this text treats in logical order, the electrical units, the electrical circuit, electric power, conductors, semi-conductors, insulators, magnetostatics, the magnetic circuit, and electrostatics. The rationalized mks system is used throughout except for the material on the design of magnetic circuits, where the English system is also given.

Notable Features:

- The book has been designed for and tested as a text for the first course in electrical engineering. Almost every topic is introduced by a completely worked out illustrative problem. Many of these problems provide important supplementary knowledge for the student. Extensive problems are given at the end of each chapter.
- The choice of material, illustrative problems, and problems for the student have been combined with 230 illustrations and a careful arrangement of topics to produce a very "teachable" book. The text is thorough but not too long for a 3–4 semester hour course.
- The book is completely up to date in technical coverage. For example, the latest theories of semiconductors and ferromagnetism are discussed in a manner suitable for the level of the book, and the student is introduced to the mechanism of current flow in semiconductors.
- A short chapter on electromagnetic waves is provided for those teachers wishing to introduce their students to these concepts in the first course.

Published in May

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Introduction to Electric Power Systems

JOSEPH G. TARBOUX, Professor of Electrical Engineering, University of Michigan

Covers the theory and operation of power-transmission systems under balanced steady-state conditions, and system characteristics under unbalanced or faulty operation, since most electrical engineering graduates in the power field come into contact with lines already built and in operation. *Revised edition (1949), 395 pages. $5.00.*

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WILLIAM M. BREAZEALE, Oak Ridge National Laboratory, and LAWRENCE R. QUARLES, Professor of Electrical Engineering, University of Virginia

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Electrical Engineering

EMERSON E. KIMBERLY, Professor of Electrical Engineering, Ohio State University

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ANNUAL MEETING—PENNSYLVANIA STATE UNIVERSITY
State College, Pa. June 20–24, 1955

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By JOHN FRANCIS LEE, Professor of Mechanical Engineering, *North Carolina State College*, and FRANCIS WESTON SEARS, Professor of Physics, *Massachusetts Institute of Technology*

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*Cloth, c. 576 pp., 199 illus., 1955 — $10.00 ($8.50)**

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By R. L. BISPLINGHOFF, HOLT ASHLEY, and R. L. HALFMAN, *Massachusetts Institute of Technology*

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After a general introduction, the book is divided into four main parts, covering: fundamentals of elasticity and dynamics of deformable bodies; fundamentals of aerodynamics which find application in aeroelasticity; equations of aeroelasticity; and experimental methods.

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Cloth, c. 875 pp., 318 illus.; to be published Summer 1955
Price to be announced.

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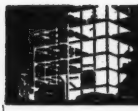

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Edited by RUEL V. CHURCHILL, University of Michigan. 233 pages, $6.00

Volume III is a collection of 17 papers presented at the American Mathematical Society's Third Symposium on Applied Mathematics, held at the University of Michigan in June, 1949. The book offers a selection of recent developments in the mathematical theory and applications of elasticity and plasticity, and represents contributions to the subject made by specialists in these fields. Grouped as far as possible according to subject matter, the papers cover such topics as extensions of approximation methods and of the general theory of elastic and plastic deformation, as well as new applications of the elastic theory of plates, shells, beams, columns, and shafts, and new methods of analysis of stresses in elastic and elastic-plastic structures.

FLUID DYNAMICS. Volume IV

Edited by M. H. MARTIN, University of Maryland. 186 pages, $7.00

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Edited by JOHN H. CURTISS, Jr. In press

This volume, cosponsored by the American Mathematical Society and the National Bureau of Standards, contains all but two of the papers which were presented at the Sixth Symposium held at Santa Monica City College in August 1953. It presents selections in the theory and art of computing and keeps pace with the rapid advances being made in computer technology. This excellent and interesting collection of papers represents the works of recognized authorities in their respective fields.

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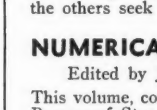
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Engineering Books

THE BATEMAN PROJECT BOOKS

Edited by

A. ERDÉLYI

California Institute of Technology

The Bateman Project consists of five books: three volumes titled HIGHER TRANSCENDENTAL FUNCTIONS and two supplementary volumes, TABLES OF INTEGRAL TRANSFORMS. The project was originally conceived by the late Professor Harry Bateman of the California Institute of Technology. After his death in 1946, the California Institute of Technology, with the financial support of the Office of Naval Research, assumed responsibility for carrying out Bateman's plans.

At this time Professor Erdélyi took staff responsibility, supervising preparation of and editing the work. The staff consisted of Professor Wilhelm Magnus of New York University; Professor Fritz Oberhettinger of the American University; Professor Francesco G. Tricomi of the University of Turin, Italy; and a staff of young mathematicians.

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Prentice-Hall

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Users of the first edition suggested many of the improvements included in this new text. Divided into 2 parts, Statics and Dynamics, the treatment and the fundamental principles are presented in sufficient clarity and detail to enable the student to grasp the content with minimum help from the instructor. The TEACHER'S MANUAL contains suggested course outlines; worked-out answers to text problems, including sample quizzes and examinations for mid-terms and finals.

In the Prentice-Hall Civil Engineering & Engineering Mechanics Series, N. M. Newmark, Editor

6" x 9" . about 640 pages . Published May, 1955

INTRODUCTION TO THERMODYNAMICS AND HEAT TRANSFER

by DAVID A. MOONEY, *author of "Mechanical Engineering Thermodynamics"*

A basic text for courses in thermodynamics and heat power engineering, for mechanical or non-mechanical engineering students, this book is a briefer version of Mooney's "Mechanical Engineering Thermodynamics." It clearly and concisely covers the basic principles of thermodynamics and heat transfer, and their applications to mechanical engineering processes.

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By VIRGIL M. FAIRES, *Professor of Mechanical Engineering, North Carolina State College*

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WILEY BOOKS

Uses engineering terminology . . .

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DYNAMICS of MACHINERY

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By R. K. Frevert, *and* G. O. Schwab, *both of Iowa State College;* T. W. Edminster, *U. S. Department of Agriculture; and* K. K. Barnes, *Iowa State College*. Provides subject matter on the five engineering phases of soil and water conservation, with data on soil physics and hydrology. A volume in the Ferguson Foundation Agricultural Engineering Series. *1955. 479 pages. $8.00.*

ADVANCED CALCULUS

By Louis Brand, *University of Cincinnati*. Includes introduction to the Laplace transform and complex variables, as well as a thorough treatment of Fourier series. All proofs are given in their simplest form. Every portion of the theory is fully illustrated by examples. *1955. 574 pages. Prob. $7.50.*

TURBOBLOWERS: Theory, Design, and Application of Centrifugal and Axial Flow Compressors and Fans

By A. J. Stepanoff, *Ingersoll-Rand Company*. Deals with the hydrodynamic and thermodynamic aspects of the turboblower design. Outlines new methods of attack on turbomachine problems, and discusses the art of building turbocompressors in the United States and abroad. *1955. 377 pages. $8.00.*

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Do You Know—

► By now you know the Annual Meeting is at Penn State on June 20–24, and have received the Preliminary Program. To facilitate your planning, "How to Get to Penn State" is repeated below. It is expected most people will drive and you will appreciate the convenience of having your car.

By highway, the intersection of highway routes US 322 and Penna. 45.

By bus, the Greyhound Bus Lines from Pittsburgh, Harrisburg or Scranton, Penna.; the Edwards Bus Line from Elmira, N. Y., by way of Williamsport, Penna., and from Cleveland, Ohio.

By train, the Pennsylvania Railroad from the west to Altoona, Penna. and then by Greyhound Bus Lines (42 miles); from the east to Lewistown, Penna. and then the Boalsburg Bus Line (30 miles). To avoid excessive delay between train arrival and bus departure, schedule arrival at Lewistown or Altoona to coincide with the bus schedule.

By air, the Allegheny Air Lines from Pittsburgh and Newark to Mashannon airport and then a taxi (25 miles) to State College (University Park).

► Members of all Divisions of the ASEE are invited to visit the exhibits of the Engineering Drawing Division at the Penn State meeting. The exhibits include instruments, reproduction processes, student work, tests and quizzes. Here is an opportunity to learn at first hand the kind of work the Division is currently doing.

► The Chemical Engineering Division is sponsoring its fourth Summer School at Penn State, June 27–July 2, 1955. Typical of the technical presentations are reaction rates, process rates, fluid mechanics, solid state physics, design, and operational research; an entire day is devoted to mathematics in Chemical Engineering; accrediting of undergraduate and graduate curricula, a symposium on unit operations versus engineering science, and round table discussions on the teaching of the first course in various areas such as thermodynamics, unit operations, and economics are also included. Staff members of the host institution will give a series of four lectures on educational methods and a presentation on student counselling.

► As a reminder of what you read last month, these meetings are also being held at Penn State: *English Summer School* on June 23–25. *Open Conference on* the teaching of *Thermodynamics,* limited to 125 persons, on June 27–29.

► "University Park" is the Post Office address of the Pennsylvania State University, the post office being located in The Hetzel Union Building. State College is still the name of the city and it has its own "State College" post office.

► The Hetzel Union Building is a new addition to the Penn State Campus. It was financed by a student-voted assessment and alumni and administrative contributions. It was opened on March 15 of this year and its facilities will be available for all to enjoy at the Annual Meeting. It is "modern as the word go," has tremendous lounge space, reading rooms, dining rooms, grill and snack bar, TV Room, photography room, card room, game room, seven soundproof listening rooms for playing records, an art gallery, an assembly hall seating 196, and a ballroom seating 650 with an immediately

adjacent open-air deck almost as large as the ballroom. There also are offices and eight meeting rooms for student activities. Penn State justifiably can be proud that the "HUB," the letters coming from the name Hetzel Union Building, has replaced the "TUB," the Temporary Union Building moved from Lebanon, Penna., to Penn State in 1948.

► The dormitory facilities at Penn State are very extensive, a great many having been built since World War II. Those assigned to ASEE use are on campus, just a few blocks from the Union Building and the Nittany Lion Inn. The Inn is a large University-owned and operated facility for transient guests and visitors.

► A summer course in Plastic Design in Structural Steel will be held at Lehigh University, Bethlehem, Penna., on Sept. 7–15, 1955. The course is sponsored by Lehigh University and the American Institute of Steel Construction in cooperation with the ASEE and the American Society of Civil Engineers. The course is for educators in particular and is intended to enable them to introduce some of the new concepts into their teaching. The course will review the behavior of steel structures loaded beyond the elastic limit and will include the fundamental concepts of plastic analysis. Specific plastic design techniques will be presented and examples worked out. The series of lectures and demonstrations will involve the study and testing of columns, continuous beams, full-size connections, and a complete frame.

► ASEE members will be interested to know a Nuclear Engineering and Science Congress will be held in Cleveland, Ohio, December 11–17, 1955. The Congress is sponsored by the Committee on Nuclear Science and Engineering of Engineers Joint Council, of which ASEE is a constituent society. Twenty-four national engineering and scientific societies have united as sponsors and co-sponsors, the total membership of all being 250,000. The Engineers Society of Cleveland is in charge of local arrangements and Professor Donald L. Katz of the University of Michigan is Chairman of the Program Committee.

► ECPD has announced the expansion to the Detroit area of its pilot-study of the program for young graduate engineers known as the "First Five Years of Professional Development." The program, successfully tried in Cincinnati, is designed to offer the young graduate engineer a sound plan for continuing personal and professional growth.

► We are receiving enthusiastic comments on the new EDUCATIONAL AIDS catalog. Have you ordered your copy yet? The catalog is available from ASEE headquarters at $1.00 per copy.

► The office receives many requests for membership application blanks. We are happy to send them out, but remember there is an application blank on page 4 of the Yearbook. How about everyone putting that page to work?

W. LEIGHTON COLLINS
Secretary

Evaluating Good Teaching*

By R. D. STOUT

Professor of Metallurgy, Lehigh University

Introduction

In almost every University catalogue one will find a statement of educational objectives by which the college is committed to "stimulate the student in independent thinking" or "prepare him in the art of living" or "train his mind for the analytical solution of problems in industry and government." The teaching staff is the principal instrument through which the college must meet these objectives. In the selection of staff members for an engineering college there is a considerable tendency to be casual about qualifications for teaching, and to emphasize instead the requirements of ability in research.

With the instructor on the job, the administration then faces the problem of applying some sort of measuring stick to the calibre of his teaching. From conversations, I gather that department heads depend largely on the "grapevine" to learn about the performance of an instructor. This indirect information plus the professional accomplishments of the man are about all that the administration has to guide its judgment. It has, however, the advantages of time and personal contact for reaching an evaluation. The outsider who wishes to rate teaching at an institution as a part of an accreditation lacks even those advantages in his difficult task.

This paper does not pretend to suggest a procedure for evaluating teaching but it does attempt to discuss some of the factors that require consideration in the development of such a procedure. The importance of this question to the general problem of accreditation needs no comment.

The Eelements of Good Teaching

At the outset of the discussion, it must be recognized that the characteristics of good teaching are largely intangible. Anyone who recalls his own undergraduate classes can pick out certain of his instructors who have left a lasting impression as good teachers. Yet if he is pressed to explain these impressions in detail, he finds them difficult to reduce to specific items. Good teaching is a complex, built from the character and personality of the teacher, his relations to his students, and his general status and reputation as an engineer, as a faculty member, and as a citizen of the community. These factors do not readily respond to objective analysis.

The outsider, therefore, must begin with an appreciation of the limitations forced upon him. He must content himself with the outward manifestations of these intangible characteristics, as far as they can be observed and evaluated. Some of the sources of evidence will be considered here.

There are three general categories in which evidence of teaching ability can be found. They are:

a. the man's reputation and activity as an engineer
b. his reputation as a teacher among former students
c. the tools with which he teaches

* Presented at the Annual Meeting of ASEE, Educational Methods Division, University of Illinois, June, 1954.

These are the most promising avenues of approach for the evaluation of teaching.

The Teacher's Competence as an Engineer

Almost without exception, activity in engineering work is a prerequisite to authoritative teaching. Since engineering deals with things; it cannot be mastered in the seclusion of a library or private office. Both the past experience of the individual and his current professional activity are pertinent.

Industrial experience as a background is almost indispensible in the engineering field. I have seen among my students how greatly industrial work has enhanced the soundness of their approach to classroom and laboratory problems. So much more, then, does the instructor need such background.

Engineering is such a dynamic field that one is hard put to keep up-to-date even in his own specialty. The current activity of the instructor therefore must also be examined. In addition to research work and its publication other activities, such as technical committee work, consulting, outside lecturing and textbook writing are valuable as adjuncts to teaching.

The Teacher's Reputation Among His Students

The persons in the best position to observe the ability of an instructor are his students, and it unfortunate that they are *not* the best qualified for passing judgment. At the time he takes the course, the student is apt to be prejudiced by temporary factors such as his last quiz grade or the length of the latest assignment. On the basis of the student evaluation forms, it has been my experience that the students are capable of making valid comments on the performance of the instructor at the end of the term. There is relatively little tendency for those who have done well in the course to rate the instructor highly and for those who have done poorly to be hypercritical.

There are some staff members who oppose student evaluation and class it as a popularity contest. Undoubtedly there is some connection between the personal relations of the instructor and student and the rating rendered by the student. But certainly one does not have to be disliked to be good at teaching!

Probably a time lapse of one year is optimum for a fair estimate from the student. Before then he remembers the trivialities, and much later he may have forgotten the specific performance of the instructor. It is quite possible for a teacher to show very uneven quality among his courses. He may devote too much attention to those he likes and neglect the less appealing classes. It is not what an instructor can do, but what he has done that counts.

It is possible that the seniors might be given a questionnaire which would provide information supplementary to the other sources of data. The validity of such information would be hard to foretell without a trial.

The Tools of Teaching

The teaching of engineering subjects requires a number of standard mechanical aids, such as assignment sheets, lantern slides, charts, exhibits, demonstrations, and the textbook and outside references. It is helpful to observe the use to which the instructor puts these devices. In addition, it would be necessary to interview the instructor himself to learn his personal attitudes toward teaching.

One of the most significant sources of evidence is the quiz form. For one thing it is a sample of the subject matter that the instructor considers important and assumes he has covered adequately in class. Secondly, it shows the general approach used by the instructor in conveying an understanding of engineering principles to the students. A form of quiz which requires the student to reason and to apply the information covered in the course is readily recognized to be superior to one requiring only a repetition of facts

picked up in the textbook or in the classroom. It would be unrealistic, however, to expect the student to reason out solutions if he has not been given the necessary background in class. Thus, the quiz form is apt to be a reliable indicator of the teaching techniques followed in the course. Third, quiz sheets completed by the students help to show how they are responding to the efforts of the instructor. Finally, the quiz is useful as an educational device, and it is worthwhile to find what advantage the instructor takes of this fact.

There are other measures of the effectiveness of the teacher in stimulating the minds of his students. These include his use of work projects, field trips, class discussion periods, and office hours for individual help.

One comment is necessary here on the curriculum. No matter how capable he is, the instructor is circumscribed in his efforts by the curriculum in which he works. Thus, the curriculum should be examined from the viewpoint: does it foster good teaching? The connection between the two is not always recognized.

General Comments

In summary, it must be reiterated that there is no easy and accurate method for evaluating teaching; if there were we would not continue to discusse the subject. Teaching is an art and does not lend itself to objective evaluation. The human element in teaching overshadows the mechanical features to such an extent, that any suggestions that can be made here are of limited usefulness. In some respects, a "good" teacher is as hard to describe or evaluate as a "good" parent. One is forced to deal with broad generalities or trivial details without ever reaching the heart of the matter.

It is possible, nevertheless, to detect signs of inferior or superior teaching. These will be apparent as deficiencies or capabilities in the professional activity of the instructor, in his reputation among his colleagues and his students, and in his use of the tools of teaching. Certainly more can be accomplished in this direction.

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Publication as a Motivation for Advanced Students

By JOHN S. McNOWN *

Professor of Engineering Mechanics, University of Michigan

Introduction

To an advanced graduate student the goal of having his work published is a remarkably effective stimulus to sound learning. The strong motivation of an original project enables him, with only limited guidance, to develop in ways which cannot be effected by classroom assignments. Complete technical papers may be beyond him until he has completed a thesis; but from his work in specialized courses, he can prepare a note, a discussion, or a part of a composite publication.

Mature students who have had this type of experience heartily endorse its effectiveness. In conducting original projects, they broadened their knowledge of the topic, posed and tested hypotheses, collected or reviewed data, and conducted or adapted analyses. Finally, they faced the exacting labor of preparing a manuscript from the original organizing of their ideas to the final clear and logical expressing of them.

Few young students know whether an idea is novel, or have the judgment to distinguish a worthwhile problem from a trivial one. In the conceiving of a problem and in the making of occasional major decisions, some guidance is necessary. However, a suggestion or two usually enable them to visualize at least the outlines of an undertaking. Subsequently, they require from the adviser less of prodding than of restraint.

* Formerly Associate Director, Iowa Institute of Hydraulic Research.

Feasibility

Of course, if the student's work is to appear in print, publication media must be available. Fortunately, they are. With the wide variety of journals, symposia, bulletins, and conference proceedings—both domestic and foreign—an engineer has an opportunity unequalled in any other profession. Even though major journals often have a sizable back-log of accepted papers, rarely if ever is there difficulty in finding an outlet for valid contributions. Moreover, journals in such bordering fields as physics, applied mathematics, and instrumentation are interested in appropriate papers from engineers. As an illustration of the large number of outlets available, publications of the Iowa Institute during the past 10 years have appeared in 25 scientific journals and in the proceedings of some 15 technical meetings; about a third of each group were foreign.

The prevailing standards of acceptability need not and should not suffer because of publication of the work of graduate students. Editing by the adviser permits holding the student to the present acceptably high standards. Counsel is often needed in the selecting of material and in the interpreting of findings. The more difficult decisions, because of the student's enthusiasm and inexperience, may be those to refrain from saying something.

Discussions

Discussion of the published work of someone else is one type of contribution

within reach of a graduate student. Formal discussion, which is actively fostered in several of the leading engineering journals, or a discussion type of letter to the editor is particularly well suited to his capabilities. From a wide variety of current topics, he can choose one which interests him and about which he is at least fairly well informed, and he can prepare a comment ranging in length from a few paragraphs to a number of pages, and varying in content from corrections and additional bibliographic material to reinterpretation or extension of the author's findings. The fact that the author has the last word in his closure is an effective deterrent to the submitting of carelessly prepared comments.

In the past three years eight discussions have been prepared by graduate students in the department of Mechanics and Hydraulics at the State University of Iowa, and perhaps an equal number have been stimulated by correspondence with former students. Some developed from classroom assignments; others were almost completely self-generated. The projects were beneficial to the students, and the achievements reflected credit on the department.

M.S. Theses

Another type of contribution is derived from the M.S. thesis. Although not always containing sufficient material to be publishable as a separate paper, other possibilities exist. The thesis can form the basis for an excellent discussion, or a coordinated series of theses can be combined into a complete publication. Also, after a thesis has been satisfactorily completed, the investigation can be continued as an independent project or in collaboration with a staff member or with another student.

A variety of publications, mostly with plural authorship, have arisen out of theses submitted to the Mechanics and Hydraulics department at the State University of Iowa. During the past ten years, almost half of more than sixty publications of the Iowa Institute which appeared in standard journals were based either entirely or in part on graduate theses. Because of the numerical predominance of M.S. theses over Ph.D. dissertations, a slight majority were based on the former. Altogether, theses have provided a core of fundamental investigation in the Institute's comprehensive research program.

Group Projects

Contributions arising from special course work are exemplified by the results of a project which began as an advanced class in hydrodynamics in 1951 and culminated in an 82-page bulletin published two years later. Of the twelve who participated, eleven were then enrolled for at least part-time graduate work. The general subject, the Helmholz-Kirchhoff free-streamline theory, was selected for study because it is important in hydrodynamic analysis and because it served in solving several significant problems. Assurance was given to the participants at the outset that papers presenting the anticipated results would be publishable.

After completing a review of the topic and making a series of reports on outstanding references, the students undertook specific analyses. Some of these required a considerable amount of mathematical analysis, all required a detailed understanding of conformal transformations of complex functions. Because many analyses on this topic published in the past had been conducted with a disregard for the reality or utility of the result, topics, such as the form of boundary transitions and the characteristics of the deflection of jets, were chosen for their practical importance. Comparisons between observed and computed results were made for each type of flow, so that tested solutions to significant problems were obtained.

Although the eight papers in the resulting bulletin have intrinsic merit, their content is perhaps less important than

was the resultant growth of the authors. A group of young engineers, including several who were not strongly inclined toward mathematics, mastered one phase of complex function theory. They made a rather thorough survey of the significant publications including work by such giants of the 19th century as Helmholz, Kirchhoff, and Rayleigh. They applied judgment to the selection of worthwhile problems, and, before a group of critical staff members including an instructor of oral and written expression from the department of English, they presented orally their findings. Finally, they prepared illustrated manuscripts. Throughout the project, an outstanding feature was their readiness to complete an amount of study and analysis far greater than that expected for the academic credit received.

Opportunities like the one described in the preceding paragraphs may seem exceptional, but almost any specific project would so seem. Every specialized interest of engineers can profit from well directed investigations even if limited in time and scope. Students can assemble and interpret available results or complete unfinished projects proposed by workers who have neither the time nor the patience for detailed work, and they can conduct pilot studies in the laboratory. If not individually, at least in the aggregate, the accomplishment can be surprisingly great.

A laboratory project led some years ago by Dr. Hunter Rouse, Director of the Iowa Institute, illustrates a type of project entirely different from the free-streamline analyses. In a special summer course lasting only 4 weeks three projects were undertaken by teams of three advanced students. Problems had been selected which were adapted to the facilities of the Iowa Institute: (1) flow near a free overfall, (2) the effect of a sill on a hydraulic jump, and (3) certain aspects of the transverse distribution of velocity in a pipe. These men set out to complete in this very short time experiments which would lead to worthwhile papers. Two of the three projects did mature to publication. In all three the challenge of the unknown was a remarkable stimulant.

Summary

Effectiveness of the goal of publication is the common thread in the diversified projects that have been described. The topic, the technique, and even the accomplishment are secondary to the awakening of the student to the challenge of the unknown. Although less important than this primary goal, the many by-products of original investigations are also beneficial to the student. Individual projects are the embodiment of learning by doing which should form a part of the training of every advanced student. In most projects a real need is found for the use of library facilities. As assistance from members of allied departments is often required, the student participates in interchange which illustrates scholarly cooperation. Finally, in writing or speaking his piece, the student becomes truly receptive to instruction on the importance of clarity, concision, and grammatical correctness. He can then be persuaded, if necessary, to seek clinical assistance from teachers of speech and technical writing.

By the time a student has completed one year of graduate work he is sufficiently mature that he can profitably undertake an investigation tailored to fit his interests and available time. Such projects can accelerate his growth, teach him both caution and confidence, and contribute to the acquisition of elusive qualities like initiative and inventiveness. Such extensive achievement is possible because his desire to emulate productive scientists provides a far stronger incentive than do grades or credits. The habit of working toward publication needs to be acquired, and its stimulation is a logical complement to the other processes of formal education.

The Effect of the Graduate Program on the Teacher*

By PAUL F. CHENEA

Assistant Dean of Engineering and Head of Division of Engineering Science, Purdue University

The years since the war have been marked by a tremendous interest in teaching techniques for undergraduate engineering education. We have seen during this time the formation of a committee in the ASEE to foster the improvement of teaching and the organizing of a committee in most engineering educational institutions with this same objective. There have been lively discussions of this topic at national meetings and in a multitude of smaller groups of engineering educators and practitioners. The emphasis has usually been centered around the proper techniques for effective teaching and the ideal background and experience that makes an outstanding teacher. Many special programs have been established for teacher training, especially for the younger teachers and graduate students who are permitted to conduct classes. This wide interest and activity to provide better teachers cannot help but portend a better generation of engineering teachers.

There is one phase of undergraduate teaching, however, that has received relatively little attention and that is the frequent gradual loss in effectiveness which takes place in the professional undergraduate teacher over the years of his career. Today in almost all institutions we have teachers who are past masters at instructional technique but are not completely effective because of their limited knowledge of modern engineering practice or advanced subject matter. In fact the normal course of events for strictly undergraduate teachers seems to tend in this direction. It would appear to take some special effort on the part of the teachers and the administration to avoid this result.

The fact that a wide knowledge of the subject matter and its application to engineering situations is essential for a good teacher would seem to be axiomatic. In a recent interim report of the Committee on Evaluation of Engineering Education, ASEE, the committee stated "Every teacher should become a recognized expert in his field regardless of his background. For every teacher there is no substitute for knowledge of subject matter far beyond the limitations of that to be taught."

The report goes on to say that this in itself is not sufficient but that it is a key requirement. To this we all will heartily agree, but how does one keep up with the rapid advance of engineering if one directs all of his energies toward undergraduate teaching. The answer must be that such a teacher does not keep abreast of new knowledge. Something else must be injected into his daily life if he is to grow with the profession. There are many activities that can offer the needed stimulus to improve the breadth and depth of knowledge of the teacher. Occasional periods of actual practice in the profession in a responsible capacity is certainly one. Continued activity as a consultant offers many golden opportuni-

*Presented at the Annual Meeting of ASEE, Educational Methods Division, University of Illinois, June, 1954.

ties to keep abreast of the field. Appropriate research activities on and off the campus is another valuable approach. Probably the most effective however is the continued participation in graduate courses, study and research. There is nothing quite as stimulating as learning with a keen energetic graduate student.

If one looks at the undergraduate engineering program of today and compares this with that of thirty years ago it is quite apparent that much of the material in the present program is new. A sizeable fraction of this new material was once taught as graduate material. The remainder is new knowledge that has been generated by the profession, and much of it through graduate research programs. It is not unlikely that this trend will continue and that many of the future revisions of the undergraduate curricula will hinge around material now thought to be advanced and now taught as graduate subjects. Therefore what better preparation for tomorrow's teaching can there be than the teaching of some of tomorrow's subjects today.

Beneficial Effects

To be more specific there are several important and distinct ways that a graduate program can beneficially effect the undergraduate teacher. Three of these are the teaching of advanced courses, the supervising of graduate research and the conducting of graduate seminars.

The teaching of graduate courses differs from the teaching of undergraduate courses in many ways. More often than not there is no suitable text, and recourse must be had to the available treatises that bear on the subject. Further, a graduate course must reflect the periodical literature of the past and, more important, that of the present. Subject matter accumulated in this manner often possesses little continuity and must be recast to permit a clear and meaningful presentation. Frequently the literature itself is not complete, and appropriate bridges must be constructed to obtain any continuity at all. Often these gaps provide the stimulus for individual research and frequently they result in published papers that are real contributions to the literature. In short, the very act of teaching an up to date graduate course stimulates considerable growth on the part of the teacher and does much to increase his technical knowledge. This is true whether the course is primarily of a theoretical nature or one which reflects the latest art and empiricism in the field.

The good graduate teacher never reproduces a series of lectures year after year. He knows that last year's advanced course is no longer advanced in all its detail and changes are mandatory if it is to achieve its goal this year. This spirit of improvement carries over into his undergraduate teaching. He continually searches for more significant material for the beginning courses. It is most unlikely that these courses will become stale and out of date in his hands. Another effect of combining graduate teaching with the instruction of undergraduates is the change of pace that it offers. The pedagogical approach is different, and one does not get set in his attitudes and teaching techniques. A graduate teacher is much more likely to experiment with teaching techniques. He will often try some of his graduate teaching tricks on the undergraduates, and vice-versa. All of this creates a healthy environment for both the teacher and the student.

The effect of supervising graduate research is even more pronounced upon the teacher. In this activity he sets himself in the position of an expert in the field and opens his breadth and depth of knowledge to the penetrating scrutiny of the graduate student. He must not only be well versed in the literature and knowledge of his field but he must also be able to critically evaluate what he knows. In conducting graduate research a knowledge of the gaps in the scientific literature is extremely important. In all of this he is stimulated by the graduate student's intensive search for a solution to his dis-

sertation problem. It is axiomatic that the graduate teacher benefits to a degree commensurable with the students' gain in knowledge. Probably graduate research with creative students is the most stimulating experience that it is the teacher's lot to possess.

The conducting of graduate seminars is also a valuable teaching experience. Here, perhaps, more than anywhere else the graduate teacher is forced to think "on his feet" at the limit of his knowledge. Seminars which occasionally bring in the foremost engineers and scientists in the field are also extremely valuable. All graduate teachers sooner or later encourage their undergraduate students to attend advanced seminars. Even though the subject may be "pitched" at a level which is too advanced for the undergraduate, an occasional exposure has benefits. It opens the eyes of the undergraduate to what lies ahead of his present studies and gives him a better perspective of the future.

Powerful Stimulus

To sum up this paper it can safely be stated that graduate programs offer a powerful stimulus for improving undergraduate curricula and teaching. The present trend towards more emphasis on graduate education cannot help but portend a greatly improved undergraduate program for the future.

Mathematics Division of The American Society for Engineering Education

Annual Meeting Pennsylvania State University

June 20-24, 1955

The Mathematics Division of the American Society for Engineering Education will meet at the Pennsylvania State University, University Park, Pennsylvania, June 20–24, 1955.

On June 20 Dr. Abe Pepinsky, Chief of Psychological Services, Norristown State Hospital, Norristown, Pa., will address the luncheon meeting on the relation of *Fourier Series and Timbre.* During the afternoon session D. L. Thomsen, International Business Machines Corp., will answer the question *Can Computers Speak for Themselves?* Then Ray Pepinsky, Pennsylvania State University, will discuss the X–RAC and S–FAC and give a demonstration of these computers.

On the following afternoon, June 21, in a conference and panel discussion on Quality Control the participants will be: Ellis R. Ott, Rutgers University, The State University of New Jersey, *Statistics in Engineering and Engineering Education: Basic Concepts;* Enoch B. Ferrell, Bell Telephone Laboratories, *Statistical Applications: Electronics;* Frank Wehrfrite, Esso Std. Oil Co., *Statistical Applications: Chemical;* Milton E. Terry, Bell Telephone Laboratories, *Statistical Applications: Research.*

Dr. R. S. Burington, Navy Department, will give his address as retiring chairman on *For what Careers should we Train Mathematicians?,* June 22. This will be followed by a conference on Linear Programming: A. W. Tucker, Princeton University, *Mathematics of Linear Programming;* M. M. Flood, Columbia University, *Applications of Linear Programming:* Alan Hoffman, Bureau of Standards, *Computing Linear Programs.*

On Thursday, June 23, the mathematics part of a joint conference with the Educational Methods Division and the Physics Division will include: George W. Patterson, Burroughs Adding Machine Co., *Abstract Mathematics and the Design of Networks,* and Robert J. Wisner, Haverford College, *Some Remarks on the Theory of Matrices and Their Application to Engineering Problems.*

Requests for housing should be addressed to John B. Nesbitt, Chairman, ASEE Housing Committee, 208 Main Engineering Building, University Park, Pennsylvania.

C. O. OAKLEY, *Chairman,*
ASEE Mathematics Division

Nuclear Education for Engineers*

By A. M. ANDERSON

Manager, Engineering Training and Education, Engineering Personnel Department, Engineering Services Division, General Electric Company

Introduction

On May 24, 1954, Mr. F. K. McCune, General Manager, Atomic Products Division, General Electric Company, was talking on Private Reactor Development at an Atomic Industrial Forum Panel. During his discussion, he outlined succinctly the position of the General Electric Company in the atomic power area by four statements:

"First—we at General Electric believe that electric companies will own and operate a number of atomic power plants within the next 10 years.

"Second—we believe some of these will be full scale and they will generate electricity at competitive costs, possibly within five, certainly within ten, years.

"Third—we believe that this will be accomplished without continued government subsidy for production plant construction or operation, and that government supplied fuel will be priced at cost of production levels.

"Fourth—we believe that two nuclear reactors best suited for earliest and most effective competition with conventional fuel plants in this country are (a) the light water moderated and cooled boiling reactor, and (b) the graphite moderated water cooled reactor. These, we think, hold the greatest promise in the years ahead."

From your point of view, two pieces of information probably result from this statement, first, this is going to be a big business; and second, an inference, engineers will be needed so we had better get busy producing them. In addition, this might be accepted as a signal to direct some of the educational processes along certain channels, the channels of teaching the technology of water-cooled reactors, and if the prognoses are correct this possible educational system might produce some engineers reasonably proficient in these areas. However, before we accept this solution, let's take a tour behind the scenes and gather some more data, which will help guide the future direction of our plans. Here we might be interested in one basic issue which will provide a wealth of information. If, somehow, we could determine what technical problems are confronting the engineer working in this atomic power business, we might then infer what types of education would help him in his work. If secondarily we could ask him what he perceived to be his difficulties in understanding, we might have a measure of sorts of the validity of our inference. Then having these data we would be in an excellent position to chart a course of action for engineering education.

To take this tour we must be careful to avoid classified data, and to insure that this is properly done, I have selected problems which have previously been stated publicly, but have been careful to select those which are truly representative of the development and design functions. I have purposely omitted problems of an equipment manufacturing and marketing nature, not because they are unimportant, but because an understanding of the issues in the first two cases yields a large measure of understanding of the

* Pressented at the Upper New York Section, Annual Meeting of ASEE, October 23, 1954.

last two cases. These problems, five in number, are grossly stated and represent five large areas of technical understanding in this business.

1. A pile is a massive structure having many materials with dissimilar thermal expansion coefficients. Structurally, the parts must remain intact and care must be taken in certain sections to insure that relative dimensions remain fairly stationary over wide ranges of operating conditions, as for instance the coolant passages. The heat generation per unit volume is ideally quite high, not only because this leads to fewer pounds of core and internal structure per kilowatt of capacity, but because shielding must be wrapped around the whole structure. The stress analyst must, therefore, know where and how the heat is generated, what the limits and rates of change of operating conditions are, what the allowable stresses are in light of the high internal radiation densities, the influence of coolant and other physical conditions on corrosion, and then he is on the threshold of being in a position to apply his understanding of the laws of elasticity to his problem. As might be expected, his analyses and postulates may well influence the coolant system and complete structural system, hence he must be cognizant of the heat transfer and, to a certain extent, the complete design considerations.

2. Some materials absorb radiation, others pass it through to a large degree, based on their "cross-section for neutron capture." This property is a function of the nuclear arrangement of an element and involves the metallurgist—and perhaps the metallurgical engineer—in the physics of metal structure. Selections of materials must sometimes reckon first with the required nuclear properties and then consider the usual criteria of strength, elasticity, and corrosion resistance. In the latter respects, the problems are like those of other process industries, but this unconventional approach often restricts the choice of materials and consequently freedom of design.

In some instances, materials of extreme purity are required, far beyond today's commercial standards. Since some of these needs appear basic rather than temporary, entirely new standards of production and of acceptance testing are arising in certain fields. Closely related is the problem of getting such high quality without excessive cost premiums. Ultimately the effect could be to raise the standards in several fields of materials engineering, with benefits not limited to the nuclear industry.

The metallurgist also faces the problems of technique in his determination of properties of metals. A radioactive material may require remote handling for physical testing, as well as for metallographic polishing and etching. If photographed directly, it will cloud the film. New techniques must be developed. And the metallurgist too must inquire whether intense bombardment will affect the properties of materials. Here the practice must be linked to studies in physics of the solid state. In effect, the engineering is related to scientific findings which are just now emerging.

3. The chemical engineer uses the familiar techniques—distillation, absorption, extraction and other unit processes. But here he deals with extremely precise processes in which the yield may be a very small part of the original input, and therefore complete reactions and exact proportions become unusually important. In separating fissionable U-235 from the more stable U-238, only 0.7% of the original material is even available as potential nuclear fuel.

To complicate the task, the design and operation of any process must be such that absolutely no source or fissionable material is lost. For these items, accountability from start to finish must be complete. This is the law, and its purpose is not only to forestall unauthorized use of these valuable elements, but to prevent the personal hazards of letting radioactive material be mislaid or lost. Some isotopes remain strongly radioactive

for thousands of years, so absolute material control must be envisioned in design and operation.

It is not by accident that radiation damage to personnel is almost unknown and that the incidence of even the common industrial accidents is extremely low. Considerations of safety are paramount in all research, process designs and operations.

The design of equipment often contemplates that both control and maintenance be conducted remotely. Instrumentation and control methods must be workable and accurate in fields of radiation, and optical developments may be required where direct viewing is not feasible. Aside from the expense and embarrassment which always accompany "second guessing" after a plant is in operation, access for changes is difficult, sometimes impossible, where high levels of radioactivity occur.

Again, rates of process reactions and of corrosion may be influenced by radiation, and the data will not necessarily follow patterns established for stable elements. Even a heat balance might have to reflect the energy emission of some short-lived elements, here today but changing. So the chemical engineer likewise encounters problems outside his usual fields, and will have need to branch out.

4. The heat transfer analyst encounters odd physical configurations and sometimes deals with extremely high heat flow intensities. To analyze what is possible, he has to resort to basic properties of fluids—specific heat, conductivity, viscosity, density—to arrive at proportions not usually found in the literature. As always where one depends on high rates of heat transfer, there is the need for maintaining them, month after month, against surface deposits which might soon reduce the transfer rates. Here the problem leads into one of extreme chemical purification to avoid such deposits. Our analyst must consider also whether the heat transfer fluid itself will absorb enough radioactivity to require a second transfer medium before this special aspect can be dismissed.

5. The basic proportions, or lattice structure, of a pile are always a subject for further study, i.e., the arrangement of uranium fuel elements, coolant paths, radiation-absorbing materials and controls. If one would establish an improvement here, he must tackle first a problem of nuclear physics—the generation and conservation of the flow of neutrons. But the proportions established in the design must also allow for well-placed and sure-fire controls, and must provide space for elements of sturdy mechanical design and reasonable access, as well as for adequate flow of coolant. All this becomes a problem for a team combining the talents of the physicist and those of the design engineer. And if the engineer is well-grounded technically, this association plus further study will enable him to understand the nuclear phenomena which underlie his design.

6. Seldom has a new field of scientific and engineering effort resulted so quickly in an enormous capital investment. The present plants in aggregate have cost billions and there is some prospect of further major expansion. The very first facilities, built without pilot plant or semi-works experience, were successful due to sound analysis, creative and thorough design. The same kinds of continuing effort have brought major improvements and economies in both the original and the more recent plants.

Beyond the present accomplishments there is, nevertheless, a major opportunity for systematic engineering—economic analysis of existing plants and practices and of economic interpretation of technical developments which will lead to profitable peace-time uses. Here the methods of analysis are much like those of other industries, but the problems often involve technologies that are new. There is little experience as a guide.

7. The power level of a reactor must be controlled quite precisely, since by its very nature the reactor tends to increase

its reaction rate without limit or decrease toward zero. Fortunately, these rates of change are not too rapid except in very extreme situations so the gross reaction rate is physically controllable. In no sense, however, must this be construed to indicate that the man who develops the controls has a simple task. First, he must determine reliable means of detecting reaction rate and its rate of change. Then he must construct a system which will alter these rates, possibly by inserting or retracting neutron absorbing material; and finally he must provide some sort of safety system to produce an overall fail-safe plant.

Present Educational Patterns

If we examine present undergraduate curricula and attempt to determine the utility in the nuclear engineering field of the understanding gained, we might reach this conclusion. Each kind of engineer that we now produce will find a challenging job for his special talents or at least for certain major parts of his understanding in this new area. However, from some of these problem descriptions, it is apparent that certain changes are in order principally because of the obvious breadth and slightly non-conventional aspects of these situations which our young B.S. engineers face.

The two changes that seem paramount in importance are:

1. Increase the scope or breadth of understanding of the young engineer in the classical fields.
2. Improve his understanding of the principles of the structure of matter and behavior of radiation.

Note that I have very carefully used the word understanding and not the word knowledge, a distinction I would like to emphasize in this manner. If one observes a series of isolated events and duly records the impression in his memory, then it is fair to say that he has knowledge of these events. If, in addition to this, he is able to postulate a principle which under differing conditions of application logically infers the occurrence of the isolated events, then he has the beginnings of understanding in this area. As he continues this course of action and builds a consistent and well integrated body of principles, his understanding becomes more fundamental. This procedure is by no means a mechanistic procedure, but it requires creative talents of the highest order, and it is this understanding of principles which is our goal in education.

Here it becomes apparent that the two changes proposed will probably produce some time conflicts in present curricula, but in a few instances, at least, with which I am familiar, some courses with the objective of presenting present engineering practices could well be replaced with courses of different objectives. For instance, attempts at presenting current practice are fraught with the dangers that the end result of a deductive process becomes the sole objective, and that the system deteriorates into a memorization of specifics. This should in no sense be construed to indicate that realism should be overlooked in the process of learning, but it does mean that more freedom must be permitted the student in defining the boundaries of his deductions. Also as a corollary, we should encourage the student to define for himself the precise nature of a general problem, for in this manner he obtains practice in the inductive processes so important to the creative mind. In a very real sense, then, I am saying that the premium is paid for the young B.S. college graduate with a high thinking quality and a sound groundwork of understanding of physical principles, and with these characteristics the specific knowledge required on his industrial assignment can be readily learned during his career.

The question might next arise, "but when does a man start to become more specific in his choice of physical fields of understanding, because he obviously cannot continue forever in the direction of

learning everything about everything." It appears to me that a convenient time to start this specialization, or preferably a narrowing of the scope of study, is at the M.S. level, and it is probably quite appropriate to continue this procedure through the doctorate level. Again, however, there should be close attention paid to the breadth of the area of understanding outlined as the goal of this highest academic level, and, therefore, to the rate of narrowing of the scope from the B.S. level upward. This is becoming particularly true in the nuclear engineering field as the density of attention devoted to problems shifts away from the pure research toward an applied research and development category, where the breadth of the problem increases as indicated in the earlier problem descriptions.

Then, a specific recommendation would be:

1. Do not teach nuclear engineering specifically, as an undergraduate curriculum.
2. Lay the foundations upon which a young man can build a nuclear engineering career, either through going directly to work or continuing his study.
3. As a part of this foundation, increase the emphasis on the structure of matter and on basic principles, and decrease the emphasis on practice.
4. Examine carefully the scope outlined as an objective at the B.S. level, and the scope for the Ph.D.

Conclusions

I would like to present, in conclusion, two points which will serve to strengthen these recommendations. By definition, progress means change, and the prudent educator, therefore, moulds his student in the manner which yields the highest probability that not only will he survive the change, but he will be able to take the leadership in effecting changes. This necessitates teaching those things which are most stable and enduring in such a manner that creative talents necessary for stimulating evolution are not restricted.

As further evidence of this point, taken directly from the nuclear energy field, consider the problem of separating fissionable material from fission products. A very fine course in this separations technology could be prepared and it might, in fact, be useful. However, the man we need is the one who creates a novel and far simpler method of separation, and I have no assurance that this will even remotely resemble our present practice.

As a final potentiality, the man who would really do us the most good might find a method of combining hydrogen or other light nuclei in a manner which yields electrical energy directly. Perhaps it's only an idle day dream, but if it ever does occur, we will then need educated engineers to exploit this new area to its utmost.

Objective Testing in Mechanics at the Michigan College of Mining and Technology 1948-1954

By C. J. PRATT

Associate Professor of Physics, Michigan College of Mining and Technology

Immediately following the second World War departments of instruction on many campuses were confronted with the problem of instructing and assigning grades to a greatly expanded student body. In most cases there were several sections of each course being taught at different hours by different staff members.

The problem of how to assign grades equitably is of long standing. This report is a record of how one department on one campus has attempted to solve it. The impetus provided by the great influx of students during the years 1946–1948 gave rise to an achievement testing program in an attempt to make sure that students doing the same level of work would receive the same grade for the course though they might be in different sections and under different instructors. Beginning with the fall term of 1948 all grades assigned in general physics and engineering mechanics in this College have been based exclusively on the results of objective testing.

The subject matter included in the courses designated as "Mechanics" in this article is the mechanics section of general physics and two or three terms of engineering mechanics, depending on the course of study being pursued by the student concerned. All of these subjects are currently taught in the Physics Department of this College. Each course is one of the prerequisites of its sequel.

From the beginning of this testing program the major emphasis has been placed on the construction of adequate test items since no measuring instrument is better than the parts of which it is composed. For our purposes the multiple-choice item has proved superior to the other commonly used types. At first, five choice items were constructed, but recently the number of choices has been reduced to four, e.g.,

> A slender rod is six feet long and weighs 128 lb. Its moment of inertia about an axis normal to the rod and passing through the rod two feet from one end, expressed in slug ft², is:
>
> a: 16 b: 12 c: 28 d: 37

If it is desired only that the student show his ability to use the transfer formula for moments of inertia in the problem shown above, he could be given the expression for the moment of inertia of the rod about the transverse axis through its center of gravity.

The construction of an item in which the distractors will appear to be feasible to students who do not fully understand the principles involved is a difficult operation. Much practice in item construction improves the test builder's skill in designing items which will discriminate between those who can and those who cannot perform the important operations in scientific and engineering problems.

The first step in item construction is to outline the aims and content of the area to be tested. The individual items should be referred to other staff members teaching the same subject for a check on

the validity and accuracy of statement and answer. Student reaction is a good indication of the "face validity" of the item.

It has been found that from fifteen to twenty-five items will keep the best student busy for an hour, depending on the difficulty of the items. A two-hour final examination may have from thirty-five to sixty items. In this way adequate sampling of the principles and techniques of the course has been made possible.

The fact that a test may be valid does not insure that it will discriminate among the achievements of the good and poor students. The best possible item is one that the better students will get right and the poorer ones will miss. Because of lack of personnel and mechanical equipment, only about ten percent of the items on file locally have been so analyzed.

One of the more difficult operations in test building is to construct equally difficult, but different, forms of the same quiz to be given to sections meeting at different hours. If it is found that the level of difficulty does apparently differ from form to form, it is possible to run separate frequency distributions for the different forms. At Michigan Tech all mechanics sections take the same two-hour final examination at the same hour to assure that the same instrument is used in measuring all the students.

New quizzes and final examinations are built each term, and the items are mounted on 5″ × 8″ cards for filing. A library of quiz items collected over a number of years makes test construction easier and improves the quality of the product as time goes on. Copies of old quizzes and final examinations together with their score distributions are kept on file for subsequent analysis and possible reuse in special cases.

In a typical test booklet the printed answer sheet constitutes the last page. This arrangement reduces the opportunity of transferring unauthorized information from student to student. Computation sheets and scrap paper are collected with the booklets. No account is taken of work leading to the answer to each item in a test. It is believed that the instructor has had plenty of opportunity to observe the students' performance during the term while they have been under instruction. It is hoped that the "small errors" have been eliminated during periods of instruction so that he can be measured on the basis of his ability to solve the problem completely and correctly at the time he is tested.

Template is Used

In correcting the answer sheet a template is used to aid in counting the number of correct responses. Blank spaces as seen through the holes of the template are marked in red, and the template is then removed. The number of wrong responses is then counted and divided by three (the number of choices less one) to serve as a correction for guessing to be applied to the number of correct responses. This operation yields the "earned score" or the number of items the student KNEW how to work. Expressed as a mathematical equation:

$$S = R - \frac{W}{N-1}$$

in which S is the earned score, R the number right, W the number wrong, and N the number of answer choices for the item.

For a fifteen-item quiz the value of S has a possible range from negative five to positive fifteen, where R and W can vary from zero to fifteen and N is four. A sample quiz may yield an actual distribution of earned scores from zero, and occasionally lower, to a positive value equal to the number of items on the quiz, depending on the difficulty of the quiz and the level of achievement of the students being tested.

During a twelve-week term it is customary to give three or four unit quizzes and a final examination in a given course. This poses a question relative to the com

bination of the scores earned on the separate tests. Each earned score actually represents the numerator of a fraction, the denominator of which is the maximum score on that test. Since it is not permissible to add fractions with different denominators as they stand, the next step was to devise a method of expressing the earned scores from different quizzes in terms of a new unit so that their combination would not violate the rules of mathematics.

As an example, let us consider any frequency distribution of earned scores for 276 students. One solution to the problem would be the following sequence of computations:

1. The mean earned score;
2. The mean deviation (md) for each earned score;
3. The standard deviation (s) of the distribution; $s = \sqrt{\frac{\Sigma (md)^2}{N}}$
4. The standard score (z) for each earned score; $z = \frac{md}{s}$
5. The T-score for each earned score. $T = 10z + 50$

Regardless of the mean or range of the earned scores, we thus have a measure of the student's achievement expressed in terms of the standard deviation of the distribution of these earned scores. The relative weight to be assessed to each test is entirely in the hands of the staff members concerned with the task.

On the basis of past observations for groups of this size the range of z-scores would be from minus 2.5 to plus 2.5, or from 2.5 standard deviations below the mean to a like amount above. The reason for translating the z-scores into T-scores is to eliminate the negative numbers and to change the decimal fractions into integers. Thus a corresponding range of T-scores would be from 25 to 75. The mean earned score of any distribution would have a T-score of fifty regardless of its absolute value.

A simpler alternative operation is the determination of "normalized T-scores" obtained in the following manner. The actual frequency distribution of the earned scores for the 276 students on a recent quiz is shown below.

Score S	Freq. f	Σf_{up}	P	T
18	10	276	98.2	71
17	22	266	92.5	64
16	14	244	85.9	61
15	30	230	77.9	58
14	37	200	65.8	54
13	33	163	53.1	51
12	21	130	43.4	48
11	20	109	35.9	46
10	19	89	28.8	44
9	23	70	21.2	42
8	9	47	15.4	40
7	9	38	12.2	38
6	14	29	8.0	36
5	3	15	4.9	34
4	3	12	3.8	32
3	5	9	2.4	30
2	4	4	0.7	26

Step 1. Find the subtotal of the frequencies up from the bottom for each earned score (Σf_{up}).

Step 2. Compute the percentile (P) for each earned score, where

$$P = \frac{1}{N}\left(\Sigma f_{up} + \frac{f}{2}\right).$$

Step 3. For each percentile there is a normalized T-score which is read directly from a table of T-scores (see end of article).

Sample computation: $P = \frac{1}{276}\left(200 + \frac{30}{2}\right) = 0.779$

The sample computation indicates that a student with an earned score of 15 has ranked better than or equal to 77.9% of the 276 students who took this quiz. From a table showing areas under the probability curve it appears that 77.9% of the total number of cases will lie to the left of a vertical line 0.8 standard deviation above the mean. Hence, a percentile of 77.9 corresponds to a normalized T-score of 58 and for every other percentile there is a unique normalized T-score. Such a conversion table is given at the end of this article.

After each quiz the student is given his percentile for that unit of work which fixes his rank according to achievement in the group as a whole, which is all we try to do. The corresponding T-score goes into the class record to be combined with others, on which his final grade for the course is determined.

When several tests are given over a period of time and the corresponding T-scores are added or averaged, there results a "regression" toward the mean. It is therefore customary to spread either the sum or the average of the unit quiz T-scores as a new frequency distribution to determine normalized T-scores corresponding to these sums or averages as the case may be. This effectively removes the regression and gives each student a single T-score (T_q) based on the several quizzes which can be combined directly with the T-score earned on the final examination (T_f) in whatever ratio seems advisable under the circumstances. Locally the final examination counts 50% toward the final grade in the course.

In this way we have arrived at a single score which is a measure of the student's achievement by which he can be ranked with his fellows with complete objectivity. How the final grades are assigned rests with the staff members who have that responsibility, but this method makes it possible to do a competent job in that operation.

Collateral Benefits

Collateral benefits are many, of which two are outstanding. First, the instructor spends all but five or six hours a term teaching the course instead of continually concerning himself with the problem of evaluating the student's progress. Second, the analysis of the course content required for an adequate testing program requires a continuing effort toward its improvement.

During the seven-year period covered by this study, 1663 students have successfully completed the mechanics sequence at this College. Of these, 1337 have graduated, 137 have left school without graduating, and 191 are still in school on this campus.

Positive coefficients of correlation ranging from 0.6 to 0.8 between mechanics grades and all-college averages indicate that this type of testing program provides a good indicator of future academic success in college.

P	T	P	T	P	T	P	T
99.9	79	91.2–92.6	64	44.3–47.9	49	4.9–5.9	34
99.8	78	89.3–91.1	63	40.8–44.2	48	4.0–4.8	33
99.7	77	87.3–89.2	62	36.6–40.7	47	3.3–3.9	32
99.6	76	85.6–87.2	61	32.6–36.5	46	2.5–3.2	31
99.4–99.5	75	83.2–85.5	60	29.0–32.5	45	2.0–2.4	30
99.2–99.3	74	80.3–83.1	59	26.0–28.9	44	1.6–1.9	29
98.9–99.1	73	77.9–80.2	58	22.2–25.9	43	1.2–1.5	28
98.5–98.8	72	74.1–77.8	57	19.8–22.1	42	0.9–1.1	27
98.1–98.4	71	71.1–74.0	56	16.9–19.7	41	0.7–0.8	26
97.6–98.0	70	67.5–71.0	55	14.5–16.8	40	0.5–0.6	25
96.8–97.5	69	63.5–67.4	54	12.8–14.4	39	0.4	24
96.1–96.7	68	59.3–63.4	53	10.8–12.7	38	0.3	23
95.2–96.0	67	55.8–59.2	52	8.9–10.7	37	0.2	22
94.1–95.1	66	52.1–55.7	51	7.4– 8.8	36	0.1	21
92.7–94.0	65	48.0–52.0	50	6.0– 7.3	35		

• • • YET-ITUDES*

• *yelps and helps for the young engineering teacher*

Contributed by CYET
PHIL WEINBERG, *Chairman*
University of Utah

LEE HARRISBERGER
Editor of YET-itudes
N. C. State College

"Industrialitis?"

This is the season of the year that gives the wives of young engineering teachers a hard time. This is the month when the recruiters make their salary offers, the senior gets signed up for his first job, and the students ask the faculty whether to work for this company at "four and a quarter" or take that job for "four hundred."

This is the time when the YET goes home to "la" spouse and raves and roars about how his students are getting starting offers that often equal or better his own teaching salary. He bellows about the inequities of life; he figures he ought to be out there designing rockets, or something; and teaching ought to be retired to instead of from; etc., etc.

These wife-directed verbal epics are the manifestations of an occupational disease of YETs called "Industrialitis." The symptoms are a severe pain in the paycheck complicated by "thwartitis," "left-out-ishness," deflated ego, and "selfpityosis." All are brought about by a drastic exposure during the spring months to a concentrated atmosphere of industrial recruiting.

There isn't a YET in the business who doesn't catch a case of "Industrialitis" to some degree every spring. Unfortunately, there are too many YETs each year who do not survive the disease and fail to return to teaching in September.

This occupational hazard has cut into the YET ranks heavily in the past few years. As a result "extensive" research has been undertaken to determine the susceptibilities and immunities to the disease as well as effective therapeutic devices which can be used to combat it, once it is discovered.

It was discovered that YETs suffering from a deficiency of surplus operating capital were extremely susceptible and virtually impossible to cure. It was generally noted that those persons with the greatest "capital pains" failed to respond to any other stimulant.

In general the studies show that a generous income is the best immunity to "Industrialitis." However, since all YETs suffer some degree of austerity, all catch the disease. Those who survive, it was discovered, generally do so in spite of an anemic checkbook. This has led researchers to investigate the other factors which are contributing to recovery.

It was found that the perennial YET is a particular "breed-of-cat." He puts his professional values in several baskets and considers each as singularly important as the other. Thus, when the disease catches him he soon recovers on the strength of each of the factors. It's pretty hard to give up six "good deals" for one—even if the one is "mo dollah."

Since so many YETs find it increasingly

difficult to fight off "Industrialitis" each spring, the investigating committee recommends the following "home remedies" for building up the strength.

Dose: Frequent consideration until pain is relieved.

- How about the terrific personal satisfaction in having a part in the intellectual growth of capable students, in being able to guide a student toward enlightment?
- Think of the unlimited challenge to devise new and better techniques for motivating and encouraging a student, presenting a subject or developing a student's creativity. We haven't even started yet!
- Where else can you enjoy the freedom of professional accomplishment? There's the freedom to develop a consulting practice,* engage in research unlimited,* develop new courses, write books,* accept foreign exchange fellowships, work at a variety of industrial jobs,* take advance courses, attend seminars, participate actively in professional societies and write technical articles for current publications. Where can a man have the opportunity to choose within such a scope of intellectual activity, to specialize or diversify as he chooses?
- Where else can a person enjoy the freedom from regimentation? There are no time cards, no "eight to five," no half hour lunch period. If you have to go to the bank—you go to the bank! If you have to baby sit during the day—you baby sit!
- How about vacations? Do you think you could easily trade three and one-half months "off" in the summer, plus two weeks for Christmas and a week in the spring for just two weeks of vacation "sometime during the year"?
- Where else can you enjoy the fellowship of men of intellect in all areas of study, the breadth of cultural and social activity of campus life?

By golly, this engineering teaching sounds like a good deal, doesn't it? Don't let "Industrialitis" give you "shrinkage of the perspective." We certainly hope you'll all be back in the fall.—L. H.

* (There's "gravy" money here.)

Here's your YET-itude for May: "Don't give up, YET! You never had it so good!"

ECPD Publishes Papers on Orientation and Training in Industry

A group of four papers discussing orientation and training in modern industry are now available in a publication of the proceedings of the 22nd Annual Meeting of the Engineers' Council for Professional Development, held recently in Cincinnati, Ohio. The papers were presented by representatives of four industrial firms which have been participating in the pilot study of the ECPD program known as "The First Five Years of Professional Development."

The publication includes a copy of the brochure describing the program for young graduate engineers during the "First Five Years" and a copy of the brochure reporting on "The Community Project in Professional Development" which has been studied recently in Cincinnati. Copies of the publication are available by addressing ECPD Committee on Professional Training, 328 Baldwin Hall, Cincinnati 21, Ohio.

Summary of ECAC Conference on International Relations*

Introduction

As a nation we cannot live by ourselves. The growing awareness of our interdependence with the countries about us has recently been translated into action in many ways. One such manifestation is the increased emphasis upon programs aimed at helping our friends through education in the broadest sense. Long experience has shown our educators that mere "book learning" will not satisfy the need of those who come to us for help. They need and want not only an academic education, but the kind of practical work experience in our shops and factories and offices which will allow them to return to their countries and effectively attack the problems faced there.

The following is a summary of the ECAC Conference on International Relations held in Urbana, Illinois on June 17, 1954, as a part of the 62nd Annual Meeting of the American Society for Engineering Education. The panel was under the Chairmanship of Dean Francis M. Dawson of the State University of Iowa and had as its announced theme: *Encouragement and Development of Opportunities for Work Experience for Foreign Students.* The speakers were chosen with the view of bringing together men with different outlooks on this subject. The points of view and the speakers representing them were:

1. The Colleges. Arthur Hamilton, Dean, University of Illinois.
2. Sales. H. T. Maser, Foreign Student Director, International General Electric Company, New York 22, N. Y.
3. Government. Joseph Cushman, Division of Immigration and Naturalization, Chicago.
4. Manufacturer. W. J. Holmes, Allis Chalmers Mfg. Company, Milwaukee, Wisconsin.
5. Foreign Operations Administration. Fred K. Bollman, Development and Management Section and Leeds Gulick, Works Study Program.

H. L. Hazen, Dean of the Graduate School, Massachusetts Institute of Technology and Chairman of the International Relations Committee of the Society, was a prime mover in the organizing of this conference.

The entire forum was recorded on tape and later transcribed. However, as the program lasted well over two hours, condensation proved necessary. The following is an attempt to summarize the salient points of the proceedings in convenient form.

The following passage from a letter written by Dawson to Hazen was offered as a keynote for the afternoon's discussion:

"It should be emphasized that foreign students have to learn not the American way of doing things with big machinery which is not available to them in their own country. They need to learn, rather, about the thoroughness and meticulous care with which engineers in this country plan all operations in order to minimize waste and make for increased efficiency. Examples of this are production methods and quality control. I wish to point out from experience that it is quite silly to have men trained in the use of heavy earth-moving machinery, for example, when the real necessity is for

*Held at the Annual Meeting of ASEE, University of Illinois, June 17, 1954.

thorough planning and careful detail so that work in their own countries may be efficiently and effectively carried out."

Dawson extended this by remarking that engineers being trained for work in the so-called underdeveloped countries need less emphasis on the purely theoretical or scientific side of engineering and more on the "know-it-yourself" type of training so that when they go back home they are able to show the workers and others how "things should be done."

The foreign student needs also to learn something of the "dignity of common labor from the American industrial system in which no sharp distinction between management and labor exists," Dawson urged. "Something must be done," he went on, "to make some of these foreign students feel that they would not be losing caste if they got their hands dirty."

Dawson then introduced Dean Hamilton of the University of Illinois, pointing out that he was in charge of foreign students' relations at Illinois and particularly qualified to speak on the problem by virtue of the fact that his school is presently serving 550 foreign students, approximately 350 of whom are engineers.

Dean Hamilton:

Dean Hamilton began by crediting his colleagues with doing things for the foreign students while he failed to do as much for them as he would like. The biggest thing that can be done for these students, he went on, is not what can be done for them in college, but "what they can get from practical training outside after finishing theoretical training in college."

Quite good theoretical training is available almost everywhere in the world, but in many places laboratory facilities are either poor or completely lacking. He cited the example of a small university in Guatemala City where he had seen the laboratory equipment for nine scientific departments stored in a safe approximately six feet by six feet by four feet. He cited other instances in support of the general point that many countries are woefully lacking in the facilities needed "to give adequate preparation from the know-how angle."

Hamilton agreed with the Chairman that it would be well if the concept of work as an "ennobling process" could be more widely inculcated, but he expressed serious doubts that even so "efficient a country" as the U. S. could break down the "prejudice of ages" in six months or even a year and a half. To exemplify the nature of the problem, Hamilton told of a student, a foreign national, who had come to him much disturbed because he was unable to find a suitable body servant. This man professed never to have dressed or undressed without the aid of a servant. How long, asked Hamilton rhetorically, will it take to change the viewpoint of an individual with that kind of background?

The Illinois Dean protested that the one-and-one half year training program for foreign students graduating in this country is inadequate. It does not give them time enough to get the kind of industrial experience they need. Moreover, the shortness of the period operates against the students' chances for finding jobs, as most industries feel that in an 18-month period they have to put more into a man than they can get back.

The problem created by the short time allotted foreign students on a student visa is aggravated by the fact that people who come here from abroad under exchange visitor visas may stay for three or four years. "It seems to me," urged Hamilton, "that as this program is designed to get us friends . . . something must be done about bringing these two kinds of visas together and giving them all the same privileges."

Though not professing to know exactly how long a time would be needed to give foreign graduates from our schools adequate industrial experience, Hamilton insisted that a year and a half is too little. He concluded by urging Immigration to lengthen the work period for students

and to equalize the period for all classes of visitors.

Mr. Maser:

The second speaker introduced by the Chairman was Mr. Maser, Foreign Student Director of The International General Electric Company. Maser began his talk by recalling "enchanting tales in ancient history, telling how pioneers travelled long and weary miles to pray for the things not prevalent in their own country." With such pilgrimages began the exchange of goods and knowledge between countries. Such exchange, he declared, is beneficial, and the need for it continues to the present.

Modern business serves principally three major groups: its customers, its employees, and its stockholders. The foreign operations of a business help all three, not only by increasing efficiency and lowering costs at home, but by decreasing disease and poverty (the seeds of war) abroad.

For over half a century business leaders have been training people abroad. This was necessary if foreign operations were to continue and expand. The companies simply saw the need, selected the people, and trained them—some as foreign representatives, some as dealers, some as customers, and still others to help in foreign industrialization. Some of this training was done in the plants in this country; much of it was done directly in the foreign field.

"Companies in foreign trade have come and gone," Maser continued, "but despite these fluctuations, people from foreign countries continue to be trained by companies here." He reported that a questionnaire, mailed by him to 200 companies, had to date elicited 90 responses. Of the 90 firms replying, 67 train foreign students as against 23 which do not. Fifty-eight of the firms which replied filled out the questionnaire in full. Their responses indicated that traing was being offered in a wide variety of work, including all branches of engineering; that the training varied in length but was mostly for about one year; and that 50 of the 58 programs had been started within the last 10 years. The various programs upon which information was obtained presently include 156 men from 43 countries. Maser estimated that these 58 companies had trained 2900 men from 65 foreign countries at a cost, in living allowances to the men alone, of over five million dollars.

In speculating as to whether these data could be extended to industry as a whole, Maser conjectured that the resulting figures would be higher than would appear logical. While making no claim that either his own company or industry generally was engaged in this work from philanthropic motives, he concluded with the following comment on his own company's activities in this area:

"We have had foreign students in the General Electric Company since 1893. During that time we have brought in about 1700 foreign students. We feel that it has been of great benefit to us. We feel also that it has been of great benefit in cementing relations between our country and nations abroad. And we feel that our program has been helpful in creating good relations internationally."

Mr. Cushman:

Mr. Cushman, described by the Chairman as a representative of "the government side," pointed out that as Deputy District Director of Immigration and Naturalization for the Chicago district it was his duty to help administer the Immigration and Naturalization law for that area. This work involves a great many categories of people, only one of which is the "foreign student." The law, Cushman went on, defines the foreign student as "an alien having residence in a foreign country from which he has no intention of abandoning, who is a bona fide student qualified to pursue a full course of study and who seeks to enter the United States temporarily and solely for the purpose of pursuing such a course of study." The job of his office Cushman

described as that of seeing "that a foreign visitor maintains the status for which he was admitted to the U. S. and departs from the U. S. when his objective has been gained and his visit completed."

Speaking of the frequent requests which come to him for help in finding some means by which foreign students who have completed their college training and 18-months practical work period may stay in this country, Cushman pointed out that such help serves to defeat the purpose for which the educational program was designed and to transform it into a sort of immigrant-recruiting program. However, the possibility of a foreign student's having his status changed to that of an immigrant does exist if his country's quota is not oversubscribed. But each time this is done, warned the Immigration Department official, the purpose of the program —that of returning trained men to areas where they are needed—is frustrated.

Addressing himself to the question of how long a foreign student may stay before he ceases to be a student, Cushman said: "Frankly, he ceases to be a bona fide student when he loses his desire to complete his objective and return to his homeland." The regulations now read 18 months, he went on, and must, as long as they so read, be enforced. The McCarran Act was designed to prevent people from entering the U. S. under one status and remaining under some other. Emphasizing the magnitude of the problem, Cushman pointed out that people come into the U. S. at the rate of 170 million entries a year.

Cushman then urged that the schools explore and define exactly what the needs are for practical training time and then work with the government to get the kind of regulations they need. At the same time he called attention to two types of complaints with respect to foreign students that come to his office: 1) American students complain that on-campus and off-campus employment is reserved for foreign students, forcing the native student to look far afield for work. 2) The foreign student in practical work is accused of taking employment from the native worker. This latter complaint, Cushman pointed out, would reach greater proportions if economic conditions were to get worse. "When a man is hurt," Cushman concluded, "he hollers. If an alien is involved, he hollers to us."

Warren F. Holmes:

The Chair next introduced Warren J. Holmes of the Allis Chalmers Mfg. Co. in Milwaukee. Holmes first told a story of his experience in the Philippines to illustrate how strongly the idea is held in some parts of the world that labor is something reserved for the lower classes. Usually the foreign students we receive from overseas, he went on, are from upper-class families. "By giving these students experience in our shops and factories where the good work of our land is performed, we can contribute to the breaking down of the class consciousness which contributes to social unrest."

"The training of foreign students," said Holmes, "is a long-time and regular practice at Allis Chalmers. It is an activity in which the company's management takes particular interest and pride, but there are limitations as to what the company can do."

Addressing himself first to the positive side, Holmes pointed out that each foreign student who returns to his native land is a potential goodwill ambassador not only for the industry by which he was trained but for America as a whole. There are now, he said, 7000 Venezuelan students in the U. S. "Properly handled these students and those that follow them should, upon returning to Venezuela, become a vast reservoir of good will between this important neighbor to the south and the United States." The benefits to be derived from these programs Holmes described as of two kinds: first, the indirect benefits which accrue to the nation as a whole as a result of improved economic conditions abroad; second, the

direct benefits which accrue to the company as the men they have trained return home and acquire positions of influence.

Turning then to the limitations as to what industry could do along these lines, Holmes stressed the high cost of offering such training. The cost to his company of giving two years of training to a foreign student was estimated at $15,000. Another limiting factor noted was the resurgence of foreign competition for the world market. "It would not seem wise to me," said Holmes, "for every industrial manufacturer to train British or German or Swiss or Japanese student engineers outside of those they use for their own operation."

The result, according to Holmes, is that only a relatively few of the many application received by industry from foreign students can be accepted. "American industry," he concluded, "is alive with the value of providing work experience for foreign students. But there are those inevitable considerations to sound business—costs, facilities, and competition —which limit industry's ability or willingness to participate in such a program."

Mr. Bollman:

The Chairman next introduced Mr. Bollman, the first of two speakers representing the Foreign Operations Administration, who asked permission to refer to his agency as FOA. (Mr. Bollman quipped that a few hours at the ASEE Convention had made him lose any feeling of self-consciousness over Washington alphabet soup.)

Bollman told the group that Mr. Gulick and he were present as representatives of the Industrial Technical Assistance Division (ITAD) of FOA. The ITAD consists of three branches: 1) The Technical Aids Division which supplies literature and such materials to people who have been in this country on the program; 2) The Technical Assistance Overseas Branch which takes care of requests for technical advice and help from other countries and has personnel going abroad to work; and 3) Technical Studies, U. S. Branch, of which both Bollman and Gulick are representatives. This division consists of four sections: 1) The Professional Engineering and Scientific Studies; 2) Development and Management Studies (Mr. Bollman's section); 3) The Work Studies Training Program (Mr. Gulick's section); and 4) The Processes and Technical Studies.

There are, said Mr. Bollman, 1951 participants under the Technical Studies, U. S. Branch, of which 772 are now in the U. S. Though this is no longer a new program, dating back to 1949–50, Mr. Bollman described the cooperation of industry as highly gratifying.

After a few remarks about the general operations of this program, Bollman turned to the question, "How can you (educators) use FOA to supplement the training of your foreign students?" The answer is that if it develops that a foreign student at a school in this country on a purely academic course needs practical experience, his adviser in the school can prepare an application to the student's sponsor in the home country for a continued training course in the U. S. under FOA. "That application is reviewed, and if it can qualify as a contributing factor to the current productivity program in that country, it will be processed and a formal application made to FOA in Washington for such training. In Washington it goes into the hopper and is handled in the same way as the 1951 projects mentioned earlier."

Bollman then went on to describe another program which he felt might appeal to educators. Despite cooperation from industry, he pointed out, there is considerable difficulty in placing many of the men who have graduated from schools abroad but wish to come here for practical experience. The FOA, he said, has developed with considerable success a plan for putting these people into our vocational high schools for part of their work. The advantage of this over university training, Bollman pointed out,

lies both in the people who attend and the equipment available. In a vocational high school, he concluded, they are placed in the company of "young Americans who are learning a trade or a skill and there they have an opportunity to work with their hands, get their hands dirty, and associate elbow to elbow with an American worker. Now it's not easy to sell some of these foreign nationals on that idea. But we are doing it and succeeding, and in this way these men are getting practical work experience, increasing their knowledge of the democratic ideas that prevail in this country, and learning that there is something in the dignity of labor."

Mr. Gulick:

Mr. Gulick, also of the FOA, described for the group the manner in which the Work-Study Training Program operates. This he described as a program for the "bench-level workers" who "in the future will be the leaders of the great masses . . . in those countries which are now friendly to us and which we hope will remain friendly."

The men trained, said Mr. Gulick, are between 22 and 33 years old, have completed apprenticeship and two years as journeymen, and come largely from the metal trades. Their countries are informed through our government of the Work-Studies Training Program. Biographical data on the applicants for training are sent to this country.

In this country preparations are made to accommodate a group of from one to two or three hundred. The agency goes into five or six cities which have at least fair employment ratings. There, continued Mr. Gulick, we talk to manufacturers, to the Chamber of Commerce executive, and to the leaders of the active unions. We talk also to other interested people such as the YMCA secretary, leading pastors, and acknowledged community leaders. We then ask a school recommended by both labor and industry to make a job survey. From this we learn what industry in the area expects the labor market to be in the near future for each of the crafts. We total the number for each craft for the cities in which we are working, divide the total by three, and assume that in three months we can place that number. These men are then ordered over from Europe. An attempt is made to draw them proportionally from the participating countries, but the ratio is also affected by the availability of men who wish to come.

After the men arrive in this country, they are cleared for security and taken to the area in which the jobs exist. Each man is taken by the FOA's supervisor in that city to the factory. Here he is interviewed. If he qualifies, he is given a job at the same pay as an American worker.

For a year he is an American worker and shares their experiences. He joins the Union and pays dues. He has the vacations and long weekends. Sometimes three or four of them will buy a car and tour to California and back during their vacation. A few have taken plane trips to Hawaii at their own expense.

But, Gulick went on, the men are not without supervision. In Chicago, where there were 65 men in one project, one full time supervisor was paid from FOA funds. He was assisted by an associate-supervisor from the CIO, who proved very useful in finding jobs. A full time secretary and an office were also maintained for the project.

In addition to gaining work experience, the men also studied English and American civilization. They studied management problems sufficiently to become conversant with industrial problems from the management standpoint. They also studied union organization, labor problems, and labor management. They learned, moreover, that our productivity, which exceeds their own by 30% to 100%, does so not merely because of machines, many of which they have, but because of

better factory placement, methods, and the like.

Thus in 12 months, Gulick went on, a man really gets a picture of America and of the laboring man's lot here, and he is better able to resist the blandishments of those who try to lure him with second-hand accounts of the perfection available in Soviet Russia.

The 12-months program Gulick described as neither too short nor too long. If it were longer, the men would become settled, and want to stay here. As it is, he reported, a few marry here and then try to come back. Many marry girls here who have immigrated from the man's own country and take them back home with them. But, concluded Gulick, even those who do return don't come back before they have had a few months in which to tell their story effectively.

Mr. Roland:

The Chairman next introduced Mr. J. W. Roland, of the Department of State. Roland explained that at this meeting he represented the International Educational Exchange Service (I.E.S), a branch of the Department of State which has in the last "couple of years become increasingly concerned with giving practical experience to foreign visitors to this country." This concern was said to stem from a growing conviction that "more would be accomplished if the experiences of foreign visitors are not confined to the theoretical and academic on the one hand or to programs of generalized observation and consultation on the other." As a result of this thinking a separate division of I.E.S. has been established. This new group, the Specialists Division, is concerned, insofar as it deals with foreigners, with giving practical training experience to these people.

Under this program, Roland explained, no attempt is made to place anyone in industry directly. The program is operated almost entirely through cooperating agencies, both contractual and voluntary. The student program of the Department of State is administered by the Institute of International Education under contract. But State is responsible for the planning of the program, the general supervision, and for selecting the people to come. These fall into four main groups.

Before discussing these four groups, Roland digressed to explain that the objective of this program is "to increase international understanding." Since we are trying to build favorable attitudes toward the United States, Roland continued, we look for people who are going into government and political life and will be leaders in that field. We look also for people who are active in all forms of community activity, for people going into journalism and writing generally, and for leaders of youth organizations. Roland explained that while no group is ruled out, the aim is to find leaders in as many areas as possible.

In differentiating the State Department program from the FOA program, Roland pointed out that FOA, where the two operate in the same country, deals largely with the economic and technical people, leaving the others to the State Department. Where there is no FOA program, the State Department may tackle any field. The difference between the two programs is one of primary and secondary objectives. FOA has as its primary objective economic and technical development and as its secondary objective the development of a "wider appreciation and understanding of American institutions, motives and policies." With the State Department these two objectives are reversed.

Roland then described in some detail the four groups of people for which the State Department is concerned to find practical experience and what it does for them. Briefly summarized these are:

1) Students coming in under United States grants. There were 997 of these last year out of a total of about 30,000 foreign students in the United States. In addition, State gave Fulbright Travel

Grants to about 1000 more who had found their own schools and scholarships. The State Department encourages all these students to get practical experience in their field, but does not assist them to do it.

2) People who are brought here on specialists grants of the Department of State, primarily for a program of practical training and experience in their own field. This group is small, about 200, and contains relatively few technical and industrial people. Those on this program are financed by the State Department except for newspaper men who are paid by the papers on which they work.

3) U. N. fellows and scholars. These are serviced by the State Department to the extent that in-service training is to be arranged in or through United States government agencies. About 150 applications for this kind of service are received annually. The people are maintained by their U. N. grants.

4) People sponsored by their own governments. The people in this group and in group three are trained largely in government agencies from which they may be reassigned to private industry for all or part of their stay. These assignments are in an extremely wide range of occupations.

Roland outlined, in conclusion, the following obstacles encountered in placing people:

1) limitations of time and staff;
2) danger of revealing trade secrets;
3) danger of foreign competition, generally;
4) reluctance to accept people from nationalized or socialized industries;
5) reluctance of plants doing classified work to handle people not cleared for classified jobs; and
6) the unemployment factor.

Roland's talk completed the initial round of speeches. Chairman Dawson, after introducing Professor R. P. Sinca from Dinbad, India, to the group, commented on the work of the panel. He expressed the view that though the members of the panel had interestingly outlined their own very worthwhile programs and the problems encountered in them, little had been said that applied directly to the question of how colleges and universities can do more to secure practical work experience for the foreign students that they are graduating. This, the Chairman insisted, is of primary importance. The mere interchange of people between countries is not enough, said Dawson, pointing to France and Germany as a classic example. "The ideas behind our program are what are important. We have got to make friends with these people and see to it that they do not go home frustrated if we are going to accomplish anything."

The Chair then recognized Dean Hamilton who stated that in view of the fact that 4000 foreign engineers graduated from American colleges last June, the figure of 156 foreign students trained in 58 large industries, cited by Maser, was not very impressive.

Maser responded that he had been somewhat misquoted. First, they were not all big firms; and second, they were not all 58 industrial firms. His survey, he went on, was designed to get a sampling of what business in general is doing for foreign students. He added that he had gained the impression from the survey that industry is very much interested in the general program and that many firms which had once trained foreign students but are not doing so now would be glad to cooperate again if asked.

Mr. Gulick then took the floor to suggest that the universities might profitably copy one aspect of their program. The FOA has, he said, what is called a Labor-Management-School Committee made up of representatives of schools, management, the C.I.O., and the A.F. of L. They represent the community to F.O.A. and are helpful in getting men placed in industry. Universities, Gulick urged, should try to set up similar relationships.

Dean Everitt of the University of Illinois then asked if there exists any or-

ganization through which information regarding the possibility of placing foreign students can be obtained. He pointed out that there is at present a great deal of "criss-crossing and wasting of effort" and asked about the possibility of some organization such as FOA operating as a center to find out just how many jobs are available for foreign students.

Everitt then theorized that the 4000 foreign students graduating in engineering could probably be given training in American industry without undue strain if all possibilities were systematically developed through some central organization. Recognizing that this would be expensive, Everitt urged, however, that it would cost far less than other types of foreign aid. Even if a survey were to show that only 1 in 10 or 1 in 5 foreign students could be placed, Everitt added, this would be useful as it would allow the schools to plan the foreign student's program realistically.

George Lobingier of Westinghouse was recognized next. He offered the opinion that the programs for training foreign students have never been effectively sold to management at the policy-making level. He also endorsed Everitt's suggestion that a clearing-agency be created and said that such an agency could do much to help sell top management.

Mr. Sherman Royal of Technical College, Scotland, told the group that they too are training foreign students. He expressed the view that these men could be more easily placed if they were required to have practical experience in their own countries before they were accepted.

Chairman Dawson responded that it was his practice to examine all aspects of an applicant's background, including his work experience. The Chair then recognized John Gammel of Allis Chalmers Co. who raised the question as to whether or not the ordinary undergraduate engineering program was suited for all of the people who come here and suggested that some work in a technical institute might be included.

George Mullin of Technical Recruiting, General Electric Co., said that people in his work must constantly take time to explain to foreign students that they cannot be hired on jobs involving government contracts. He proposed that much time could be saved for everyone if a bulletin were printed which set forth clearly the work areas open to foreign students and those open only to U. S. citizens.

In response to a question from the Chair as to whether all of GE's plants were classified, Mullin explained that though some of their plants are not classified, it is necessary in the building of a professional staff to hire men who can be used flexibly as their abilities and the company's needs warrant.

Cushman then offered the information that many firms have applied for permission to import engineers from abroad for use in unclassified work. "I don't know the answer," he said, "but somewhere here there must be an answer, as they are importing these people who cannot become citizens for five years and putting them to work immediately in plants where classified contracts are being offered."

Mr. Gulick explained that the responsibility for admitting people to plants working on defense contracts rests with the representative of the Department of Defense at the plant.

Dean Vivian of the University of Southern California commented that he felt that it was highly important to impress upon foreign students that practical experience is a privilege and not a right.

In response to a question from the floor as to how a foreign student who is in this country as a private citizen on a student visa can enlist the aid of FOA in securing practical experience, Mr. Bollman advised that the student write directly to the FOA mission in his own country. This should be done early as it takes

about twelve months to get the application through.

Mr. Cushman was then asked whether a man on a student visa could be paid a wage or salary. He replied that such a person could be gainfully employed.

Professor Black of Iowa State College then said that he had been plagued with the problem of getting experience for foreign graduate students. Many of these, he explained, badly need practical training before they can do graduate work profitably. Black commented also that he felt the government agencies should do more to clarify their own objectives and the regulations affecting practical experience for foreign students.

Cushman replied that the government agencies do try to coordinate their efforts. That they sometimes fail to do so perfectly, he pointed out, should not surprise people from large universities where the same kind of problem exists. The establishing of an information agency that could answer everyone's questions about all aspects of the government's complex and voluminous activities would be quite expensive, Cushman added.

Hamilton then directed a question to Cushman regarding the possibility of getting a year of practical experience for a foreign student going to school here on a student visa before that student has completed his college course.

Cushman replied that under the law practical training in advance of the academic program cannot be approved. A student may, however, apply for a change of status to exchange visitor. However, he cannot change his status again without returning to his own country.

Mr. Bollman suggested that it would probably be better if more students came as exchange visitors, for they then could take any combination of academic and practical training that their sponsors approved and their programs called for. Bollman added that his department is conducting a survey of the possibilities for finding practical experience opportunities. This survey should clarify the picture somewhat.

The point was then made (speaker not identified) that the urgency of action in this area is dramatized by statistics which show that while we trained 23 people from Indonesia last year, Russia trained 9000.

Another unidentified speaker then emphasized the great importance of sending those people who do receive training here back to their home countries prepared to do the work that needs to be done. He suggested that perhaps the countries from which the students come would be willing to subsidize training in specific areas that are of special importance to them.

Bollman then reminded the educators that FOA does provide a definite procedure through which the schools can obtain practical experience for their students and again urged that use be made of the facilities of the vocational high schools for this purpose.

In conclusion, Chairman Dawson expressed the belief that the International Relations Committee should work out some concrete plans and arrange for a conference in Washington.

Conclusion

Though the Conference did not produce any simple answer to the question of how to provide more opportunities for work experience for foreign students graduating from American engineering colleges, two very important points of agreement are apparent in the foregoing proceedings:

1) The representatives of education, industry, and government agree that enlightened self interest requires us to continue and expand the program of sharing educational opportunities with our friends abroad.

2) Practical work experience in this country is, in many instances, an essential supplement to theoretical training in colleges and universities.

The proceedings reveal also that there are many factors which now seriously

limit the program for giving practical work experience to our friends from abroad. Paramount among these are security needs, fear of competition, prejudice, apathy, limited facilities, complex and sometimes conflicting regulations, and lack of information. The need is apparent for cooperation at the top level among the schools, industry, and government to determine: 1) what work opportunities are available to foreigners; 2) how the number of such opportunities can be increased; 3) exactly what can and cannot be done under existing laws; 4) what changes are needed in the laws; and 5) how information of all kinds can be made readily available to all interested persons and groups.

Several proposals designed to promote more effective cooperation among the interested groups were made during the discussion. The International Relations Committee of the ASEE intends to follow through on these.

American Society for Engineering Education

Chemical Engineering Division

Fourth Summer School for Chemical Engineering Teachers

The Summer School will be held June 27–July 2, 1955 at The Pennsylvania State University, University Park (State College), Pennsylvania, following the annual meeting of the parent society. Three earlier Summer Schools for Chemical Engineering Teachers were convened at the University of Michigan (1931), The Pennsylvania State University (1939) and the University of Wisconsin (1948). All were very successful. As will be the case for the forthcoming sessions, emphasis was placed on practical help to the teacher by discussion of instructional methods and the presentation of illustrative problems.

Program. A varied program has been arranged under the general direction of Dr. Kenneth A. Kobe of the University of Texas. Technical presentations on reaction rates, process rates, process control, fluid mechanics, solid state physics, design and economics, and operational research are included. An entire day is devoted to mathematics in chemical engineering. Topics of great interest to teachers and administrators are: Accrediting of undergraduate and graduate curricula; a survey of undergraduate curricula; nuclear curricula; a symposium on unit operations *versus* engineering science; round table discussions on the teaching of the first course in chemical engineering, thermodynamics, unit operations, and on design and economics. A series of four lectures on educational methods and a presentation on student counseling will be given by staff members of the host institution.

Meeting Place. It is planned to hold the sessions in the air-conditioned Assembly Hall of the new Hetzel Union Building. Round table discussions are scheduled for various rooms in Osmond Laboratory across the street from the Hetzel Union Building.

A Professional General Curriculum in Power*

By JOHN A. M. LYON

Chairman, Department of Electrical Engineering, Northwestern University

Any subdivision of Electrical Engineering, particularly at the undergraduate level, seems arbitrary; training in a so-called option is not always purposeful. At the graduate level a much greater depth in specialized training seems justified. Although even here it is often difficult to classify a man by the frequently used categories "power" or "communications." Consider a man who has received his Ph.D. with original research in some part of basic Electrical Engineering, such as semi-conductor development. Each of us can see immediately the utilization of advances of this subject in either power or communications equipment. Let us recognize that labels are often misleading. Power industry personnel representatives very often say that they are not interested in the particular specialization within Electrical Engineering in which a student has studied. In this way I am led to conclude that we mean by power equipment manufacturing, or by power generation, transmission, and distribution, something very broad which requires above everything else good basic training. Actually the quality of the instruction and the competence of the faculty are more important than a list of the courses taken by the student.

We may very well wonder at this time what we mean by the term "power." I do not consider "power" to be synonymous with "d-c" or "60 cps" nor do I believe that "electronics" is the exclusive of the communications people. I use the word "power" as an adjective or classification to describe the production, transmission, utilization, and control of electrical energy. The power may be produced electronically, or electromagnetically, omitting other possibilities for brevity. With this meaning in mind, I am talking of a curriculum of interest to utilities, utility equipment manufacturers, control and instrument manufacturers and users, users and makers of high frequency process equipment, and the users and makers of a wide variety of digital and analogue computers.

Certainly in electrical manufacturing as well as in the production of electrical energy we must be cognizant of the electron tube, semi-conductor devices, and the saturable reactor as control elements. Renewed interest in dielectric and magnetic materials for a wide variety of purposes will bring advances in many branches of electrical manufacturing. With respect to the electric power industry I believe we all readily come to the conclusion that electric and electronic control, and instrumentation constitute a tremendous part of the activity. We in the power field must realize that electronics is as much a part of the field of endeavor as are network theory, and electricity and magnetism. I think that it is very regretable that electronics has been considered by some to mean "non-power," "communications," and the like. Somehow I think industry has been less to blame in making this incorrect distinction than the colleges and universities. At least in industry there was some excuse. A man who had had no electronic training hid under the name of "power." Communications people who first used

* Presented at the Annual Meeting of ASEE, Electrical Engineering Division, University of Illinois, June 18, 1954.

so-called electronic devices were eager to seize upon the word "electronics" as something that belonged exclusively to them. I am afraid that colleges and universities have been guilty of agreeing to this misleading concept.

Many of use in college teaching together with our contemporaries in industry recognize the great need for studies involving more than one field of engineering such as electrical, mechanical, civil, etc. Industry has been helpful in the problem of determining the patterns of engineering education. I wish to point out that education has contributed, and must in the future contribute to the shaping and moulding of industry. Things that are being taught in the university classrooms and discovered in the university laboratories may very well be a part of the future of any industry.

In planning a power curriculum we should look to the future of the whole power industry in much the same manner as the utility system planning engineer. We should teach so that the student is prepared to meet problems in industry including the newer and most advanced problems. However, if we attempt to teach the student to handle the details of the individual technical problems, we would then be surely short-changing the student on fundamentals. Any curriculum in electrical engineering should be of sufficient depth so that the student upon graduation will have something technical to offer which is not available generally from graduates a few years before him.

I think that we should not strive to place students in classifications any more than necessary and justifiable by precedent. Just as industry makes use of individuals with different abilities and interest so should colleges and universities recognize students as individuals with very real differences. In so far as possible I believe colleges and universities should strive to develop the student along the lines of expressed interest. In this way I think the student is most likely to approach his full potentialities in life.

Keep It Basic

I believe the main requirement of any electrical engineering curriculum is to keep it basic; a large amount of specialization at the undergraduate level is unjustified; and a special designation in the degree offered should not include reference to this comparatively small amount of specialization within the general field of Electrical Engineering. I believe experience has shown the error in detaching Radio Engineering and offering a separate degree in that specialty aside from the degree in Electrical Engineering.

There seem to me to be two general methods of approaching this curriculum problem. One is to alter existing courses to include basic concepts of the power field. The other is to include in the curriculum specific courses in the power field. This latter approach would require the deletion of existing courses.

It is my contention that the future of an undergraduate electrical engineer is largely undetermined when he is an undergraduate. I personally know that some of the finest system planning and relay engineers in the electric utility field were enthusiastic about radio communications in college. Also I know of some of my former students, mechanical engineering students, by the way, whose main contact with Electrical Engineering in the university was in the service courses offered to them—these same men in the professional world are recognized now as able electrical engineers.

The main objectives in a professional general curriculum in Power should be:

(a) To develop the intellect of the student
(b) To supply him with basic concepts
(c) To stimulate and inspire the student for possible creative work
(d) To equip the student so that he is prepared to enter his chosen branch of professional engineering with a reasonable knowledge of the latest advances in this branch

(e) To render a service to industry and the engineering profession by supplying adequate trained individuals who are not merely capable of being assimilated by the profession and industry, but who may reasonably be expected to supply the profession and industry with new impetus.

These objectives can be realized with various power curricula. A curriculum has the best chance of successfully fulfilling its objectives if it is tailored to the abilities of the faculty.

My experience with employers indicates that they place a high value on good training in mathematics, physics, chemistry, the humanities, economics and business administration, and basic courses in other engineering departments. It seems doubtful if carving out a more extensive power curriculum at the expense of the above fields can be justified. It is desirable that the student in Electrical Engineering be allowed to take a few general electives from the above fields.

You will notice that electronics is involved in power, as is analysis of circuits, nuclear instrumentation, motor control, symmetrical components, analysis of power system stability, and other appropriate subjects. I still hesitate to say that every undergraduate student who expects to be in the power field should have courses entitled Symmetrical Components, Power System Stability, Power System Relaying, LaPlace Transforms, or Tensor Analysis. Rather undergraduates should have a limited knowledge of some of these plus a general knowledge of the usefulness of the other topics. Further, it seems to me that every power student should have facility with system analysis involving circuits utilizing both electronic tubes and machine elements, including control elements. The analysis of circuits should be general enough so that the students see the usefulness of similar methods for thermal, fluid and other flow problems.

I am not going to list courses to be included in a general professional power curriculum. Rather I would say that in some of the required courses the fundamentals of network theorems, superposition, symmetrical components and transform analysis should occur. More complete treatments can be reserved for elective and graduate courses. With the tremendous requirement for a basic knowledge, I doubt if most undergraduates can take more than two or three elective courses in the technical field of electrical engineering. Even then I would not insist that these electives all be in what are generally called power electives such as "Power System Stability," Symmetrical Components," "Relaying and Control," "Industrial Electronics," etc. I can see the desirability for a power engineer to take courses in almost any phase of electronics, advanced circuit theory, analog computers, digital computers, feedback systems, microwaves, etc.

Fundamental Concepts of Nuclear Processes

In line with the idea for training for the future, it seems to me that every electrical engineer should be trained in the fundamental concepts of nuclear processes. For a power curriculum, additional elective courses in nuclear reactors, and nuclear instrumentation seem desirable. The nuclear power plant projects at present being anticipated raise the question of whether or not there should be a separate curriculum in nuclear engineering. My belief is that nuclear engineering is an excellent example of the need for cooperation among the existing branches of engineering and, in universities, among the existing departments of engineering. There is a very important phase of nuclear engineering to which electrical engineers can contribute, and that is in nuclear instrumentation and control. The important problems of thermodynamics and metallurgy can best be solved by engineers primarily concerned with such topics. In

short, I believe our basic training of electrical engineers should deal with nucleonics much as our basic training deals with thermodynamics, heat engines, or theory of structures. In electrical engineering, training for nucleonics should be concentrated at the elective and graduate levels on control, instrumentation, and particle accelerators. In this way the needs of the manufacturers and of the utilities for engineers trained in nucleonics may best be fulfilled.

The power industry has to offer challenging opportunities to young men before this industry can compete favorably with communications and radio in the employment of recent graduates. Power engineers responsible for developing the engineering personnel of their organizations should not emphasize (1) importance of knowledge of equipment (2) servitude for the young engineer in subprofessional levels for the first few years, thereby perhaps forever limiting the vision of the young man. The power industry for its own further development should try to make use of the special abilities which the recent graduates possess and which the experienced engineers never had the opportunity to obtain.

In the universities we don't want to teach men just to do the routine jobs in engineering. Unfortunately, many young graduates now entering the power field find their ambitions thwarted by the apparently common practice of reserving the most intriguing problems for the older and more experienced engineers. Actually, I believe that in the power field too much weight has often been placed on experience. There is a real danger in this. We then find engineers brought up in the atmosphere of doing the same old thing in the same old way. Sometimes I thing that we should always have two types of designers available. One type to keep up with the latest in the industry, the other to be entirely uninhibited and not be concerned with what the rest of industry does. If we had more of the latter, we would have less stagnation in certain fields.

Conclusion

In conclusion, I believe in stressing the objectives of a power curriculum rather than a listing of courses. I believe in a curriculum utilizing the strength of the faculty. I warn against boxing in the subject of power so that a student gets a worm's eye picture of Electrical Engineering.

College Notes

Four new degree programs for graduate students have been approved by the board of trustees of **Stevens Institute of Technology.** Of the four new programs, to be offered starting next fall, three will lead to the degree of Doctor of Philosophy. These will be awarded for study in the Departments of Chemistry, Mathematics and Physics which already grant the master's degree. The new doctoral programs will be in addition to that in applied mechanics now offered by the Department of Mechanical Engineering, for which the degree of Doctor of Science is awarded. The fourth of the new programs is one leading to the degree of Master of Science in Civil Engineering.

* * *

The South Dakota Legislature in its 1955 session appropriated $850,000 for a new engineering building at **South Dakota State College.** The building is being planned at the present time. Completion of building may be in 1957.

Educational Requirements for Design and Development Engineers*

By WILLIAM E. BRADLEY

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A report on the subject of educational requirements for design and development engineers must begin with the comment that we are more dissatisfied with the *quantity* of the applicants than with their quality. There has never been a time when so many challenging design and development positions were available in the communication field.

Of course the manpower shortage in these fields is only partly due to a reduction in the number of engineering graduates. In large measure it has been caused by industry expansion in highly technical fields so that there is an increasingly great demand for men capable of filling design and development positions.

I will try to present a summary of those educational requirements and related matters which seem to me to be most important. I am not in a position to judge which of these are most readily applicable to the planning of actual engineering courses by the schools. The most important subjects in this connection will be presented in approximate order of priority, from our own point of view.

Personnel Type for Design and Development Positions

It is our opinion that adequate education is a necessary but not sufficient condition for a successful engineer. Both design and development positions require, in addition, certain inherent talents and abilities. Engineering schools perform an extremely important function, in addition to their educational activity, in *selecting* appropriate personnel types.

However, a difficulty appears at this point. There has as yet been developed no system of grading students which gives much indication of the *relative* talents and abilities of the student in each subject as compared with the average of his colleagues. This comparison is very important because to some extent college grades can be used as aptitude test data. This is a much more powerful method of personnel selection than the use of *average* grades.

I have often been in some doubt upon examining a transcript of the grades of an applicant as to the value of the present grading system to a prospective employer. For example, I might observe that the applicant had a mark of C in a course in differential equations. The question that immediately comes to mind is whether the rest of the class averaged B or D since only thus can I conclude whether this man showed more than average ability or below average ability in this important course.

The grade received by a student in one isolated course is, indeed, almost meaningless without additional data. If this grade had been attended by a statement of the average grade received by the entire group in this course and if, also, there were a notation of the number of semester hours of study to which the student was committed during the semester when the course was taken, a great

* Presented at the Annual Meeting of ASEE, University of Illinois, June, 1954.

deal of valuable information could be derived. Strong individual differences between students can be distinguished from the *pattern* formed by their departures from class average in each course. Our most successful design and development men show very clear-cut patterns or correlations in this respect and we have come to the conclusion that very valuable data concerning the personnel types could be obtained by a relatively small amount of additional information furnished with the transcript of grades.

Of course we have no *rigid* rules relating mathematical correlations, derived from academic grades, to suitability for employment, but we do allow these correlations to prejudice us. It is probable that the research for correlation between the pattern of grades and industrial success in particular fields is an appropriate job for industrial personnel departments since position requirements vary from company to company. On the other hand, the development of a grading system that would make the study of such correlations possible is clearly appropriate to the educational institutions and we very much wish that this could be done.

Thorough Grounding in Basic Theory

An engineering course is necessarily a mixture of two components. One of these is training in *basic* theoretical *principles* and their broad application. The other is training in the *engineering practice* of our generation. In our experience, these two types of training are not of equal value. Basic theory does not change, whereas engineering practice does. It is impractical for engineering schools to keep entirely up-to-date with present-day practice whereas, due to their more permanent nature, engineering schools can teach with assurance fundamental physical laws.

We have many times wished that our young engineers had more training in theoretical mechanics, Fourier integrals, vector analysis, electromagnetic theory, optics, and elementary atomic physics, whereas we have seldom had reason to complain of a man's lack of knowledge of practical equipment *except* in cases where the personnel type was not appropriate.

I am sure that this point has often been made before and that our point of view here is not at all unusual. However, no account of our opinion regarding educational requirements for design and development engineering could be correct without the statement that training in fundamental physical theory is in short supply.

Application of Theory to Practical Situations

Strong differences appear among men of nearly equal education in their ability to apply theoretical knowledge to practical problems. Since a number of men have shown marked improvement in this ability during their period of employment with us, we believe that it is not an inborn talent but that it can be learned from experience. We are not certain what could be done in an educational institution to improve this ability but, surprisingly, there does not seem to be a very close correlation between an engineer's ability to solve a textbook problem, which is clearly stated in language to which he is accustomed, and his ability to deal with easier problems which arise from day to day in the course of laboratory work. Perhaps the truth here is that the student needs practice in the process of *problem definition*. To *define* a problem relating to a physical system is a kind of abstraction process. Anything that can be done to improve the engineer's ability to *relate* actual physical phenomena to the laws and principles which he has learned in school would be of immense value.

The most important factor in learning how to apply theory is, of course, actual exercise in such application. A compromise is necessary between the extent of the framework of theory to which the student is exposed and the thoroughness

with which he learns each part of the framework. The distinction between a superficial knowledge of theory and a working knowledge of the same theory is like the distinction between a reading knowledge of a language as opposed to a speaking knowledge. A speaking knowledge can only be acquired by actual practice in speaking, and a working knowledge of theory can only be obtained by applying the theory to idealized cases. The cases should be preferably idealized because the intent of the process is to fix the theory in the mind of the student. The amendments necessary for practical applications should be learned on the job, not in school.

Laboratory work in the engineering school may or may not assist in this type of training. During his college years the average student is studying so many subjects simultaneously and has so little time for relaxed thinking that he is very likely not to do justice to the challenging problems presented by even a very good laboratory course. In that respect, work in industry is very different from the type of effort required of a student in engineering school. It is the rule, not the exception in industry, for a man to spend many days or even weeks on a single subject or problem whereas in school the ability to switch off his interest in one subject and turn it on in another on short notice contributes greatly to his performance. This quality may not even be desirable in industry. The requirement that during his education a student focus his attention *in rapid succession* on many rather diverse subjects is one important cause of the well-known discrepancy between college grades and success in industry, at least for design, development, and research positions.

Training in the use of approximate methods of analysis is a closely related subject. Very rare is the design or development problem which does not involve approximate rather than exact application of mathematics. A skilled engineer not only has a repertory of standard approximation methods, such as linearization of nonlinear systems, expansion in series, approximation of integrals by sums or sums by integrals, and so forth, but he also knows how to guide these approximations by a still more vague sense of proportion derived from a clear visualization of the physical factors of the problems. Again, many engineering schools fully appreciate the importance of this subject but I would like to emphasize that its significance in practical work is very great.

Engineering Decisions

A little observation of the actual practice of engineering in industry shows that such positions require important activities for which the engineer receives very little guidance from his engineering training. It would be very helpful if a little more emphasis could be placed upon the nature of engineering decisions, upon the manner in which responsibility is allocated in engineering organizations, and on the conduct of the typical small meetings in which technical group decisions are made. These things are, at present, part of the folklore of the profession and for many years after graduation a student is likely to be reckless when he should be cautious or the opposite. He does not fully appreciate the extent and limitations of his responsibilities, and does not know how to conduct himself in a technical meeting where he may be called upon to present important evidence and to help decide important issues.

Perhaps engineering schools should make a study of some of these aspects of an engineer's work and determine whether or not these things could be taught in an orientation course for upper classmen. I have heard that some steps in this direction have been taken in a few schools.

Conclusion

It can be seen that the foregoing comments can be summarized under two headings.

First, from our point of view, we wish that we could use scholastic grades in some degree as indications of the *relative* aptitude of the student in various fields. Normalized grades could accomplish this and would greatly assist us in finding positions to fit the characteristics of the available men.

Second, we would like the engineering graduates to be prepared for the decisions which they must make in typical research and development activities. Such training should prominently feature as extensive as possible a framework of theory with plenty of practice in its application to *idealized* cases.

Some general training in the process of technical decision-making would also be appropriate, although this subject does not seem to fit existing scholastic categories and the content of such a course should be based upon observations of the actual practice of decision-making in development and design engineering organizations.

In the News

Establishment of the Office for the International Geophysical Year of the **National Science Foundation** has been announced. The new office will be headed by J. Wallace Joyce.

The International Geophysical Year is a world-wide program of special observations of various earth-science phenomena planned for 1957–1958. Under the auspices of the International Council of Scientific Unions, thirty-eight nations have already agreed to join, during that year, in a vast effort to collect synoptic data in such fields as geodesy, meteorology, the upper atmosphere and ionosphere, oceanography, earth magnetism, and latitude determinations. The purpose of the program is to develop more fundamental knowledge, which in turn can lead to direct benefits to all mankind.

* * *

The 47th and *largest* Annual Meeting of the **Air Pollution Control Association** will be held in Detroit from May 22 through 26, 1955. Membership in the national association, which is interested in all phases of air pollution control, includes representatives from industry, trade associations, educational institutions, and local, state and national groups. Air pollution control experts from the United States and Canada will report on the latest findings in smoke abatement, air pollution measurements, odor control and new developments in abatement equipment.

Evaluation of Engineering Teaching Ability

By T. H. EVANS

Dean of Engineering, Colorado Agricultural and Mechanical College

The evidence of research is a publication of results and conclusions; that of useful professional activity in a national society is work on worthwhile and active committees, or as an elective officer who leads the society to useful achievements; that of educational background is advanced degrees; that of prestige is the seekers for advice from outside the college; that of scholarship is publications such as textbooks, supplementary notes, technical papers, or discussions of technical papers of others; that of background of professional experience or private consulting practice is the concrete creations of such work.

All these activities in which a faculty member might engage are measurable and can be evaluated for merit. But what is the evidence of good teaching? Can it be measured in a similar manner? If not, how can it be evaluated?

The problem of evaluating correctly the teaching ability of members of an engineering faculty has been discussed probably since the beginning of ASEE's predecessor, SPEE. Yet no one today seems to be able to give a universally acceptable answer to the question of how you do it. Perhaps we worry too much about something that has no definite solution; but since someone *is* always worrying about it, it appears that administrators will have to keep searching for a good solution. This is an effort to define the problem in order at least to help clarify the writer's own thinking on the subject.

Methods of evaluation today seem to run all the way from pure opinion based on a teacher's habits and personality, to elaborate numerical rating systems based on publications, degrees, society activities, talks, courses taught, and what have you. What is right and fair for *both* parties concerned? That is the problem for which most of us would like to have a good answer.

Since answers will vary with just what is wanted it will probably be well to try to limit the problem with definite specifications. As the writer sees it, the problem is to determine *how effective as a teacher of engineering subjects* is the man who is hired primarily (but not necessarily exclusively) as a teacher. The problem is affected also to some extent by the administrative level at which the evaluation is being done. One above that of the departments seems desirable since in many schools that is usually final, and it is also the first level at which overall coordination and uniformity must be exercised. To boil it all down then, the writer sees it as: how may a dean evaluate properly the teaching ability of an engineering teacher? While the dean is not always close enough to the teachers to observe them at work he still has the responsibility of coordinating the recommendations of a diverse group of department heads to be sure both the school and the individual are treated fairly. Even though all department heads are sincere and unbiased, their various methods of evaluation may cover the spectrum from one end to the other.

To arrive at an acceptable definition of what good teaching is may not be difficult but there is extreme difficulty in deciding how to measure what a man is doing as a teacher. The latter is our problem. A

this stage at least we are trying to measure the man's *teaching ability* and not his overall worth to the institution.

We might start by reviewing two extremes which have been used in evaluating a teacher's ability. On the one hand we have a fairly objective method that measures a teacher in terms of advanced degrees, research, publications, activity in national societies, civic affairs and campus committees, prestige, etc., in addition to his classwork. This method has been criticized as evading the issue since most of the items used are not a direct measure of a man's teaching ability, and we know of people who do many of these things well but are still poor teachers. It also has many champions who point out that these things can measure the man's teaching ability since they are backgrounds he must have to teach engineering.

Then we can go to the other end of the spectrum and find a purely subjective system in effect, in which many human or personal traits are used as a guide. In this system the items mentioned in the preceding paragraph are looked on with abhorrence, sometimes to the extent where a department head may even discourage members of his staff from engaging in them. Factors which have been considered here are: enthusiasm, a sincere interest in the development of young people, knowledge of subject matter, attitude toward teaching, intellectual honesty, ability to inspire and stimulate others, ability for self-expression, tolerance, ability to cooperate, judgment and tact, professional attitude, originality and ingenuity, personality, etc.

This extreme has been criticized also for various reasons. For one, many of the factors listed are no more a direct measure of teaching ability than those in the other extreme. The ones that might be interpreted as directly measuring teaching ability (e.g., ability to inspire and stimulate others) usually cannot be measured in any reliable way. Since most of the items, even if directly related to teaching ability, are not capable of quantitative evaluation, the system boils down to subjective judgments. These are criticized as being liable to opinion, prejudice, emotion, friendship, or just plain charity. This method appears to have no more universal acceptability than the other at present.

The unusual and outstanding small group of distinguished teachers, some of whom we all know, are not our problem. They are usually easy to spot because everyone—students and colleagues—feel they have some spark that makes them outstanding; and then most of them do something besides just teach. Perhaps it is the latter that causes them to be outstanding. Our problem is with a great mass of engineering teachers who are not distinguished outside of their classrooms, but many of whom undoubtedly do an excellent teaching job. Also many of these better ones do not care to do anything but classroom teaching. How may an administrator evaluate properly their ability as engineering teachers?

Since the two evaluation extremes mentioned have both good and bad points, and neither has been universally acceptable, it seems that a compromise would be better to perhaps retain the advantages from both systems. This would be a compromise between purely objective and subjective methods, with a hope of being able to measure not only the quantity, but the merit of all items considered; tempered, of course, with human understanding and good judgment. It appears also that we must retain many items that may not measure directly a man's teaching ability but which, if indulged in properly, could improve it.

Instead of using a negative approach and shunning any characteristic because it does not directly measure teaching ability (having a Ph.D., or tolerance, judgment and tact, for instance), or because it could be overdone and detract from a man's teaching (too much research for example), it seems a positive approach would be much better. In other words,

if the characteristic *could* make a man a better teacher, then try to use it. It would be up to the evaluators to determine the merit of any item and to keep things under control so that poor teaching was not rewarded just because the man had an impressive record of other things. To never have any such items to evaluate for their merit is what bothers some administrators.

Now we come to the evaluation of a man's overall worth to his college. This has probably been confused a lot in the past with his evaluation as a teacher. If a man is a poor teacher he should not receive any rewards for his teaching, although he may have considerable other value to his institution. If two men seem to be about equal as teachers then perhaps one is worth more to his college than the other. This is a matter for administrative determination, but each level of evaluation must always keep clearly in mind also the objective of rewarding good teaching if it can be determined with certainty. Good teaching should also mean something special, something above average, something more than mere acceptability.

It is proposed that the good teacher is a creative man of many ideas, great originality, and enthusiasm for teaching, who will spend most of his time in professional development of appropriate kind. He should be creative whether it be in classroom teaching, writing, research or professional activities. As Julius A. Stratton, provost at M.I.T., so succinctly stated it: "Teaching and the quest of knowledge go hand in hand. A society of teachers with no interest other than that of conveying knowledge acquired by others will wither away." A school can be no better than its teachers; if they are "satisfied" men then there is a big question of its ability to progress and keep up with the times. To improve curricula and to attain prestige the engineering school must have a faculty of excellent teachers and scholars.

Too many people seem to be thinking about stereotyped drill through a subject when they speak of "good teaching." The teacher may spend a lot of time getting up his preparation from a textbook and in grading problems, but unless he does special things to get the subject across, such as novel training aids, unique laboratory equipment for demonstrating basic principles, original special problems of the integrated type, individual problems in design courses to arouse the creative desire of students, considerable supplementing of textbook material with special notes, or a gift of inspiring people, he still might not be too effective. A typical case is the loyal, conscientious worker, who without imagination, originality, or contribution of his own, religiously follows some standard text from year to year in his course.

Since the outward evidences between him who just drills his class and may be a poor teacher, and him who is really good but does nothing professionally outside of classes, are so elusive for positive identification of the real differences, we can have cases of stagnation, retrogression, or plain inability in individuals that might be hard to detect. The responsible administrators could have extreme difficulty in really knowing which was the better teacher unless there were other measurable characteristics to go by. The good teacher who is full of ideas, and trying to develop as a teacher, must keep up with his profession. To do this he must at least study the current technical literature. It seems a *minimum* outlet for his thoughts and ideas would be written discussions now and then on the papers of others. Just studying the work of others, and perhaps attending society meetings, but never writing or saying anything, gives the impression that the individual has no ideas or originality. If he has not, can he really be a good teacher? Many excellent teachers are probably going undetected by their department heads or deans because they are hiding their light under a basket.

A good department should perhaps

have balance between those who are devoted primarily to teaching and those who have broader interests. With a preponderance of either, its students may suffer lack of good teaching. A department may be dull, colorless, behind the times, and academically isolated if all its members engage in no worthwhile professional activities outside of their classroom work. It will achieve no distinction or prestige even though all its members are good teachers. Where a department head actually discourages broad professional growth because he feels it interferes with good teaching then there can be a big question if the teachers are as good as they might be. The other extreme can be bad too, but an administrator and a school would usually be better off to have to hold activities down a little than the reverse. To achieve real balance, a department must have some who engage in the different professional activities mentioned before, and then some perhaps who just want to teach.

The type of alert mind that seems essential to good engineering teaching usually would not be content to teach only within the classroom. It appears only natural that such a person would want to get his ideas out to his profession, to his fellow teachers, as well as his students. To do this he would want to speak now and then at meetings, write discussions of other's papers, write a paper himself on occasion, perhaps do some research or consulting. These outlets for the fertile mind are not "extracurricular" because most of them serve as a feed-back to keep the teacher more progressive, more alert, and professionally developing. While perhaps not directly a measure of his teaching ability they are the necessary background for teaching engineering.

After concentrating on this evaluation matter for several years now, then writing it down with revision after revision in attempts to clarify thinking further, this writer does not feel he has the answer by any means. Like all matters having to do with human behavior it is certainly not subject completely to mathematical interpretation.

It seems clear, however, that the good teacher must continue to develop his professional background, and show some evidence of scholarship beyond his last degree. If he chooses to confine all evidences of his ability to the classroom alone then he will still be a difficult case to judge. Since we need something besides pure opinion, perhaps such items as initiative, interest in students, ability to express himself, considered student opinions, knowledge of subject matter, originality, enthusiasm, ability to work with others, devotion to duty, outside reading, development of training aids, supplementary class notes, creativeness, type of problems required, character, use of spare time, etc., would be helpful in evaluating such cases. It would be up to the department head to present as much concrete evidence as possible on any items used. Some, of course, can't be judged objectively; others can. We still have human beings to deal with and must be just, fair, and unbiased. Administrators also have obligations to the students and the institution, however, and therefore need evidence to substantiate their own feelings of tolerance and charity toward their fellow men.

The cases of those who want to push their teaching, scholarship, or technical ability out beyond the classroom for the benefit of the public, or other engineers and teachers, give evaluators a lot more to go by. The man who does essentially the same things in the classroom as the teaching isolationist, but who is also more active professionally, gives an administrator much more to get his teeth into in making an evaluation. It appears this latter case should be based on all the evidence available, including the same as suggested in the paragraph above. The extra items here might be such things as publications, society activities, research, consulting, public service, current industrial experience, prestige, etc. Per-

haps the man's worth should be split into two parts—that in teaching, and that to the institution in other ways. If any of the new items introduced in this case can be shown to contribute to his teaching ability then they should be used there too. Most of these items are assessable both quantitatively and objectively for worthiness.

Taking the two cases for comparison now—both are judged on their teaching ability on the same basis for all available evidence that honestly applies. In addition the one is judged on his extra value to the institution. The individual's reward would be the sum of the two results in one case, and only one in the other. A really superior teacher (who does nothing else) could very well have a total value greater than the man who did lots of things but whose teaching was poorer. However, for two judged about the same in teaching ability the more active man professionally would reap the greater reward.

To make *any* system work it would be necessary that the dean assure himself that each department is presenting evidence on the same basis and in the same way. This in itself is extremely difficult, but if all administrators concerned honestly intend to be fair to the institution as a whole, then it must be done. If a system could be devised where points were assigned to each item it would be a great boon. However, the use of points for items is liable to become a trap because of its apparent simplicity and ease of use, since points themselves may be a matter of one man's opinion. A point system that is used only as a rough guide, the results of which are then tempered by the necessary subjective and human considerations, may be a satisfactory answer if the proper items are used.

The writer's own present conclusion after all previous cogitation is that a method of considering items that can fit into two categories—teaching, and extra—with point values used as a rough guide, and not forgetting that all this concerns human beings and not machine parts, appears the best answer until someone proposes something better. Whatever the system, all faculty should be aware of it in a general way so individuals would know definitely on what they were judged.

If such a scheme as proposed above was found worthy the details and method of application would be a matter for determination by each individual school, because of the variations in organization, faculty characteristics, and items considered important.

Comments on this subject are invited. —EDITOR.

What is Wrong with Surveying?

By MICHAEL V. SMIRNOFF

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One frequently hears discussions among engineering educators about a proper place of surveying courses in modern engineering curricula. Interest in this subject may be traced either to the overcrowded conditions of these curricula or to a questioning attitude as to the value of surveying courses in engineering education. Since engineering curricula vary considerably among engineering schools, it is necessary to point out that discussion in this paper pertains chiefly to the first semester surveying course. It is further assumed that this course in elementary surveying is required of all engineering students.

When the American Society of Civil Engineers was organized over one hundred years ago, the name Civil Engineer was used to imply a distinction from the Military Engineer. A civil engineer in those days could hardly be imagined in any other but outdoor surroundings—manipulating some tools and instruments that were supposed to determine certain lines on the ground delineating states, counties and townships, fixing property lines, locating railroads, etc. A civil engineer was then either a surveyor or a construction man, to whom the chain, the transit and the level were indispensable tools in his work. Long years of apprenticeship were required to acquire the magic skill necessary for the successful operation of these tools.

When engineering curricula in colleges began to take a definite shape, it was natural that surveying courses assumed a place of importance among other subjects to be taught in those schools. One can even wonder what an engineering student of those days could have been taught beside surveying. Concrete was unknown, metallurgy was primitive, electricity undiscovered, properties of materials, stress analysis and other prominent engineering interests of today existed in those days only through rules, applying to construction the knowledge acquired through intuition and earlier experience. Occasionally, ignorance or a mere accident produced something which was better than the expected result. The new procedures were then carefully noted and were regarded as the new standards of perfection. Everything was learned, more or less, as a trade. It took a long time for scientific experimental and theoretical approach to replace the old method of learning. However, the current methods of teaching surveying have not fully made the transition to modern methods. Surveying is continued to be taught as a trade course.

One immediate reaction to this situation may be that surveying is a sort of a trade, and as such should be taught in trade schools and be thrown out of engineering curricula. However, this position would be hard to defend. Engineers certainly would not want to call a surveyor every time they need to measure a distance, angle or elevation, as they would call a plumber to repair a bathroom fixture. Besides, if they had to do that, they would soon discover that wherever a measurement is concerned they themselves would have a lot to say about it since much in the engineering profession is done through measurements and depends on measurements.

The word surveying, according to Web-

ster, is "that branch of applied mathematics which teaches the art of determining the area of any portion of the earth's surface, the lengths and directions of the bounding lines, the contour of the surface, etc. . . ." Many people require just that to be done. Such business employs many surveyors who have never gone to a college and who have learned the trade in apprentice-like fashion. This proves only the fact that there is a place for surveying in subprofessional schools. A college graduate is not likely to go into that business unless his professional field gets awfully crowded. On the other hand a college graduate is likely to meet many situations in which he would be required to pass a sound judgment on the methods and instruments to be used in measurements.

The writer recalls witnessing construction of a through truss bridge having a 140 ft. span. The distances, center to center of pedestals bolted to the top of piers, were supposed to match the length of trusses which were assembled on the ground. The man doing the measurements for the contractor was not a college graduate but had a good training in field measurements. He made the measurements satisfactorily but he never was sure enough that his measurements were sufficiently correct. It never occurred to him that if the allowable error in measuring a span length were about one inch, the required precision ratio in measuring 140 feet would be about 1/1700, and that such precision could have been achieved by him with about one third of the accuracy that he would exercise under ordinary conditions. It is in the assignment of precision ratios and in the determination of the proper means for attaining them in actual measurements that the skill and trained judgment of the engineer is required.

The interchangeability of large parts of machinery and structures presents another example where good engineering judgment in measurements may be extremely important. The difficulties encountered in such cases mount rapidly with larger dimensions. Various optical instruments are now being designed and used in measurements where close tolerances are required.

General Principles of Measurements

A surveyor may do his ordinary land surveying work quite satisfactorily with an old transit and the like, but an engineer may be expected to know many other available methods of measurements as well as the degree of reliability that can be expected from each method and instrument. If his work deals with measurements, the engineer must be ready to answer questions about how close various parts or lines or angles must be measured and what may be wrong with a method, an instrument or a procedure. It may be expected that a good deal of information about the general principles of measurements should be acquired by engineering students in a course involving surveying.

The course in elementary surveying normally starts with explaining how to measure distances with a steel tape and how to apply corrections due to incorrect length of tape and variations in temperature, tension, sag and slope. A chapter in taping thus offers a unique demonstration as to how all systematic errors affect measurements. Derivation of formulas pertaining to corrections for these systematic errors involves the use of converging series, coefficient of thermal expansion of steel, unit stress, unit strain, unit weight and the moment of forces. However, a quick glance through surveying texts reveals that many texts in elementary surveying do not even show the derivations of all those formulas. Thus a student is obviously expected to "plug in" certain values in a formula and come out with the answer. In his next engineering course, however, he is likely to be admonished never to use a formula blindly.

The method of measuring distances

with a subtense bar * and an one-second theodolite eliminates the tape and corrections due to systematic errors, but it requires understanding of the theory of accidental probable errors. Although this particular method of measuring distances is not suitable for the first semester students, there are many ordinary rules and operations in plane surveying which are based on the theory of accidental probable errors. Since very little about these errors can be found in most texts on elementary surveying, it is customary to learn certain rules and operations without understanding the reasons underlying them. This method of learning brings inevitably that atmosphere of a "trade course" which was mentioned above.

After taping, the instruction usually passes to differential leveling with a dumpy level and a Philadelphia leveling rod. This method of determining difference in elevations follows a standard procedure which is taught and practiced throughout the country and meets the requirements for ordinary surveying work. There are at present time other levels some of which can do better and faster work. There is also on the market a self reading tape-rod which reduces the notekeeping to two columns, one for stations and one for elevations. The rod has its limitations but it is a wonder tool for certain types of work. A midwestern surveyor who used this rod for many years, mailed a questionnaire to some 50 colleges and universities asking for comments on the rod. According to his report, the answers can be approximately grouped into the following three categories:

1. Not familiar with it.	20 replies
2. Do not teach its use.	20 replies
3. Mention or teach its use.	10 replies

Three reasons may be expected to be advanced to show why college instructions in surveying must adhere to old standard methods and equipment. a) The old standard equipment can do surveying work of ordinary precision satisfactorily. b) Replacements are costly. c) Anyone who has learned how to operate the old instruments should not have any trouble with newer equipment.

These arguments tend to keep surveying instructions at a trade level and quite stationary at that. But there is no need to keep them at that level. First of all the students must be taught all the theory involved in measurements and applicable to other measurements as well as to surveying. Second, newer methods and equipment need only be used for demonstration and explanation of what can be achieved with them. Third, the acquisition of skills in operating surveying instruments should no longer be regarded as the primary reason for doing the first semester exercises, especially if they are given to all engineering students.

The dumpy level is usually followed in instruction by a transit; that good old American transit which is so familiar to engineers. It weighs about a "ton" and never fits into its own box. This instrument, which would have delighted Ferdinand Hassler, has only one thing wrong with it. Like the level, it does surveying work satisfactorily. One can see nowadays many transits of foreign manufacture which, due to cheaper production, find wide distribution. These are optical theodolites. A one-second optical theodolite is comparable in weight to a standard American transit. It can do first order surveying work and can be used with a subtense bar for measuring distances. This instrument should also find many uses in industry. These optical theodolites are fine instruments, worthy of any engineer. The writer has spent one delightful summer working with them.

The outline of the main topics in the rest of the elementary surveying course should include the stadia method, computation of areas by various methods and public land surveys. The derivation of formulas for the stadia method and the

* See writer's article on "The Use of Subtense Bar," *Surveying and Mapping*, Oct.–Dec., 1952.

areas give just as good application of algebra, geometry and trigonometry to practical problems as can be found in any lower division engineering courses. It may not be fully realized how much an entering freshman can learn in a course like elementary surveying. It may be made most helpful and useful, preparatory for a further sequence of courses in engineering.

Conclusions

In a summary the following conclusions can be made:

a. Surveying has remained for too long sedentary and on too low a plane. With newer and better equipment and a wider scope of application it could be revitalized and made more useful and interesting.
b. It is more important to teach future engineers what methods and equipment can be used to accomplish certain results than to teach what results can be accomplished with old standard equipment.
c. Since all engineers use measurements, a course in surveying could be made practically equally useful to all engineering students. It should include the fundamentals pertaining to any measurements and applicable in any field.
d. Surveying measurements are particularly suitable for demonstration of principles of measurements and should be used to accomplish that aim. The surveying part will then take care of itself automatically and in a more enlightened fashion.
e. If surveying is one of the first engineering courses on students' study program, it must include all disciplines pertaining to engineering. In fact it must demonstrate the engineering method and approach.

Although the discussion presented here had in view only the first semester surveying course, some changes may be deemed welcome in other surveying courses. In the opinion of the writer they should be revised with a view of giving priority to newer methods and better techniques. Among these, for instance, the emerging science of photogrammetry should find its proper place.

ANNUAL MEETING

June 20-24, 1955

Pennsylvania State University

UNIVERSITY PARK, PENNA.

(formerly State College)

Mechanics Conference*

The Objective of Instruction in Undergraduate Mechanics in Physics and Engineering

The conference found, after a careful analysis of the statements of the objectives of undergraduate instruction in both physics and engineering, that the objectives are not competitive in scope but actually complementary when the courses are properly planned and taught. It cannot be over-emphasized that the instruction by physicists will provide the engineering student with an understanding of physical phenomena basic to much of his later studies. On the other hand, the objective of instruction in mechanics by engineers is to achieve professional competence in the practical solution of problems encountered in engineering.

We conclude, therefore, that there is an essential difference in the approaches to mechanics by the physicist and the engineer. There is a place and, indeed, a need for both of these approaches to the teaching of mechanics. The different objectives should continually be recognized and used as guides in planning courses.

Objectives of Physics Instruction in Mechanics

The primary objective of physics instruction in an engineering or scientific curriculum is to provide the student with an understanding of the physical principles that describe nature, of how these principles have evolved, and of their scope and limitations. Such an undertaking must begin with the study of Newtonian mechanics. Great emphasis should be placed on the conservation principles. The generalization of these principles along with associated concepts has formed the basis for modern physics, including such special branches as atomic and nuclear physics and the physics of the solid state. With this approach, it is neither practical nor desirable in the physics course to devote attention to the development of facility in detailed application of physical laws to practical problems encountered in engineering practice. Stimulating problems should be selected with a view to illustrating physical principles, and it is essential that they be accompanied by a challenging laboratory experience. These courses, approached in this manner, should provide an adequate base for the student's continued scientific growth.

In order that the study of Newtonian mechanics be effective in setting the stage for a proper understanding of the concepts and methods of modern physics, it must be recognized that a significant difference exists between the older physics and much of modern physics. In modern physics a large amount of theory is often interposed between observations and the conclusions based on them. Nevertheless, the pedagogical approach in which macroscopic observations are used directly as a guide in building theory must first be employed, as it can in mechanics; the student must later be led to the present day methods of inferring conclusions regarding phenomena not directly observable. These methods are in fact used in kinetic theory, optics, and electricity, as well as in many topics of modern physics.

To achieve this goal, the role of con-

* Held at New York University, February, 1955.

servation laws in mechanics and electricity can hardly be over-emphasized. The study of mechanics should also include the dynamics of systems of particles, wave propagation, standing wave systems, etc. Valuable for later work in modern physics will be the study of resonant systems, such as the mechanical harmonic oscillator, accompanied by demonstrations or discussions of similar resonant systems in electricity, nuclear-magnetic resonance, and examples from acoustics and optics. It is in this spirit that instruction in mechanics makes a significant contribution toward the understanding of phenomena in atomic, nuclear and solid state physics.

Objectives of Instruction in Mechanics by the Engineer

The prime objective of instruction in engineering mechanics is to provide the student with a useful understanding of the methods and principles needed to design and predict the performance of real engineering systems and structures. The preparation of engineers for creative design should be kept always in mind. Creative design requires as much ingenuity, imagination, and resourcefulness in the application of physical laws and principles and making them useful to man as is required in the original formulation of them.

In order to solve real problems of the great variety and number that are presented to the engineer, it is necessary that he become proficient in a systematic method of problem solution. Consequently, instruction in methodology is an essential part of engineering mechanics. Instruction must include ample emphasis on the following operations which are basic to engineering analysis.

The student must learn to identify the essential elements and characteristics of each specific engineering problem. Is it, for example, one involving statics or dynamics, rigid or deformable bodies, a conservative or a dissipative system? He must be able to select relevant information and data and recognize those which are not pertinent. In doing this an ideal model must be created and the problem made amenable to solution. The results based on the idealized model must next be interpreted in the light of the original real situation. The engineer must form a judgment of the extent to which he can rely on the results obtained on the ideal model, and finally he must be able to communicate this to others in suitable and usable form.

The engineer must devote major emphasis to the formulation and evaluation of his problem quite apart from the necessary analysis. Instruction given the engineering student should reflect this fact.

It is in this spirit that the instruction in engineering mechanics assumes a significant role as a springboard to a truly professional attitude and approach to all engineering situations.

Objectives of Instruction in Solid State Physics

Before considering the place, if any, of solid state and nuclear physics in engineering curricula, it is desirable to consider the activities of physicists in these respective fields. In nuclear physics, the physicist is concerned with the quantitative behavior and structure of nuclei, the nature of forces involved between nuclear particles, and the interaction between nuclei and radiation. In solid state physics the physicist is seeking to develop an understanding of the properties of solids on the basis of their atomic constitution.

To take part in the current activities in either of these field requires a background and a working knowledge of quantum mechanics as well as of the general principles and conservation laws of classical mechanics and electrodynamics. Such knowledge can be obtained only through several years of study, generally including graduate work. This conference is convinced that there is no short-cut by which this knowledge can be given to undergraduate engineering students by

means of a one or two-semester course in modern physics.

On the other hand, an introductory course of one or two semesters' duration covering some of the topics mentioned above could be given following the general physics course. Such a course should broader the training of the undergraduate engineer.

It is the conviction of this conference that the time should not be taken from that now devoted to an understanding of the fundamental principles of mechanics, which should be required of all engineers. Instead, the conference recommends that the basic physics course be strengthened by greater emphasis on fundamental classical principles and conservation laws, and by an introduction to wave and quantum concepts. Inclusion of these topics is an essential introduction to the later study of solid state or nuclear physics. It is also recommended that as far as possible, such particles as electrons, protons and neutrons be used in the elementary physics course to illustrate general dynamical principles. In the case of existing two-year physics courses, it is the belief of the conference that some concepts of modern physics can be introduced without requiring additional time. In the use of one-year physics courses, an extension of time of at least a semester is recommended.

Mathematics Instruction as Related to Mechanics

It is urged that the concepts of calculus be introduced in engineering curricula as soon as possible, preferably in the freshman year, and used in physics and engineering as soon as feasible.

Conclusion

In comparing the different objectives and points of view of instruction in mechanics by physicists and engineers, it should be emphasized that the physicist uses problems and examples from experimental physics essentially for the purpose of developing by the inductive method those concepts and principles which it is his objective to have the student understand. The engineer, on the other hand, uses certain concepts and principles for the purpose of achieving the solution of practical engineering problems. This distinction should determine in a major way the essentially different character of illustrative material used in each area.

If instruction in physics and engineering mechanics follows the objectives outlined, it appears that, although some duplication of content is inevitable and even desirable, the real duplication in terms of influence on the engineering student will be negligible. On the other hand, if instruction in physics follows in any major way the direction of application to engineering situations, or if instruction in engineering mechanics fails to emphasize the professional engineering approach, then this duplication will result in a serious waste of time.

Consequently, it is evident that the preservation of the two different but mutually supporting points of view of the physicist and the engineer is a necessary condition for maintaining the progressive program of engineering education, which in these critical days is of vital interest to the entire nation.

Finally, the conference recognizes that progress occurs through continuing experimentation, and therefore recommends that such an attitude be encouraged in the teaching and the curricular arrangements of physics and engineering mechanics.

The participants in the conference were:

Dean J. W. Buchta, University of Minnesota
Prof. J. W. Cell, North Carolina State College
Prof. P. F. Chenea, Purdue University
Prof. W. L. Collins, University of Illinois
Prof. J. P. Den Hartog, Massachusetts Institute of Technology
Dean H. Fletcher, Brigham Young University

Prof. N. Frank, Massachusetts Institute of Technology
Dean L. E. Grinter, University of Florida
Dr. G. H. Hickox, National Science Foundation
Dean E. Hutchisson, Case Institute of Technology
Dean R. B. Lindsay, Brown University
Prof. J. L. Meriam, University of California
Prof. Glenn Murphy, Iowa State College
Prof. M. S. Plesset, California Institute of Technology
Prof. D. H. Pletta, Virginia Polytechnic Institute
Prof. J. J. Potter, Texas A. and M.
Prof. J. A. Sauer, Pennsylvania State University
Dr. Raymond Seeger, National Science Foundation
Prof. F. L. Singer, New York University
Prof. I. S. Sokolnikoff, University of Calif. at Los Angeles
Prof. W. B. Stiles, University of Alabama
Prof. D. Williams, Ohio State

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Report of Conference on Electricity and Magnetism in Engineering Education

A joint conference of the Electrical Engineering and Physics Divisions of A.S.E.E. has been agreed upon for the 1955 annual meeting Tuesday afternoon, June 21. The chairmen of the respective divisions, Professor J. N. Thurston, Head of the Department of Electrical Engineering at The Clemson Agricultural College, and Dr. R. J. Seeger, Acting Assistant Director for Mathematical, Physical, and Engineering Sciences of the National Science Foundation, envisioned the desirability of an invitational closed working conference to do the ground work for a constructive and informative program for the annual meeting. Dean L. V. Bewley, of the College of Engineering of Lehigh University, offered to organize such a working conference and was appointed chairman of a steering committee and chairman of the conference. The National Science Foundation agreed to sponsor the conference with the Executive Committee of A.S.E.E. and to defray the expenses of the conference.

Thirty-four electrical engineers and physicists met at Lehigh University February 7, 8, and 9, 1955, to discuss desiderata in instruction by electrical engineering and physics departments for undergraduates in electrical engineering and other engineering in view of the changing demands on engineering education. Appropriate prerequisite and concurrent mathematical instruction was also considered. The deliberations of the conference led to the assignment of various committees to formulate the collective attitudes of the conference in reports which were then revised and adopted by the conference. The following reports were adopted without dissent, with the single exception that one dissenter wished to go on record on one of the reports.

Objectives of Teaching Electricity and Magnetism in Engineering Education

The objectives of teaching Electricity and Magnetism in Engineering Education are:

(1) to teach fundamental principles from an overall scientific point of view, including their relationships to other types of physical phenomena, and
(2) to teach the application of these principles to the solution of engineering problems, including their relationships to other types of engineering.

Conceivably this might be done in a single department, but (1) is primarily in the province of physics and (2) is primarily in the province of engineering: hence complementary courses in these areas are highly desirable. In any case, it is evident that close and continued cooperation between the local physics and engineering departments is necessary for the successful attainment of these objectives.

Mathematics in the Basic Physics Courses

It is believed by this Conference that it is both possible and desirable for the fundamental concepts of the calculus—the derivative and the integral—to be introduced at an early stage in the curricula of engineering students. This introduction can be made simultaneously in physics and mathematics, thus re-en-

forcing the learning process. In this way the student should gain a deeper understanding of both mathematical and physical concepts. Calculus methods should then be used in increasing measure in succeeding portions of the basic physics courses.

If local conditions make it impossible for the department of mathematics to introduce the calculus concurrently with, or before, the first course in physics, it is recommended that certain concepts of the calculus be introduced in this physics course. It is suggested that this introduction be limited to conceptual matters, that is that it not be extended to include the derivation of a formal table of derivatives or integrals as this should be left for the appropriate course in mathematics.

The Conference further recommends that at least part of the basic physics courses—preferably electricity and magnetism—be taught with the calculus as a firm prerequisite.

As much of the mathematics as possible should be left in the hands of the professional mathematics teachers. In any event, the first two years of the mathematics courses should be so taught.

It is recognized that a major cause of difficulty and failure on the part of students in the beginning physics courses is the inadequate preparation which many of them have in high school mathematics. It is recommended that prerequisites in mathematics for engineering students be strengthened so that a minimum basis for admission into the freshman year will be adequate mathematical preparation through trigonometry.

Electricity and Magnetism in Elementary Physics for Engineers

It is recognized that the practice of engineering has come to require more and more complete knowledge of the basic laws and discoveries of pure science. Obviously then the importance of the basic training in the elements of the field of physics as a prerequisite to the professional training of engineers has increased likewise.

It is also recognized that many of today's methods in the technological application of the fundamental laws and facts may soon be obsolete. In other words, the specific nature of the engineering devices changes rapidly whereas the fundamental laws on the basis of which such devices were designed are timeless.

In recognition of this situation with respect to the enduring value of an understanding of basic principles, as distinguished from the temporary value of knowing the technical details of today's application, it is recommended that the general course in elementary physics for all engineering students be so given as to instill (1) a thorough understanding of the basic laws and principles, (2) the viewpoints found most useful in analyzing representative physical situations and (3) the application of the mathematical skills including integral calculus and elementary linear differential equations.

To this end the following outline suggests highpoints of the portion of a general course in physics that should be devoted to the study of Electricity and Magnetism. This course is visualized at approximately the sophomore level.

The outline is neither to specify the details nor the extent of the content, but *is for the purpose of illustrating the viewpoint* that is recommended in emphasizing the fundamental laws and illustrating their implications by examples, in such a way, and of such a sort, as to develop the student's ability to think clearly about these laws and to make effective use of the mathematical skills that are available to him for aid in such thinking. In this viewpoint, except for the laws and some of the basic characteristics of matter, *the facts are of secondary importance in relation to the ability to reason effectively concerning the implications of such facts.*

Outline of Highlights in Electricity

A brief resumé with respect to our current model of the electrical structure of matter.

Coulomb's Law, the concept of an electric field and the use of Faraday's electric flux concept particularly as expressed by the integral form of Gauss' Law. These expressions to be used in vector form along with the evaluation of the magnitudes in illustrative problems.

Illustrative problems, in general restricted to points, planes, spheres, and infinite cylinders.

The concept of a scaler potential, the conservative field, and the relation of the potential gradient to the previously defined electric field vector. In the introduction of the idea of potential and its relation to energy, it is believed feasible to introduce the utility of the vector dot-product in connection with the line-integral that expresses the potential difference between two points in an electric field. The elementary properties of idealized isotropic dielectrics and their effect on the potential difference between charged conductors in the simple arrangements represented by parallel plate, concentric spherical and concentric cylindrical capacitors.

The concept of an electric current, "free" electrons and the conductivity of metals, with the introduction of the concept of conductivity in connection with current density and electric field intensity, as well as the resistance of wires and other simple conductors, and the assumption of Ohm's Law.

Joule's Law, the concept of e.m.f., and the idea of the transformation of energy from some other form into electrical in a source of e.m.f. Then consideration of the energy stored in a capacitor, not only in terms of its charge and potential difference, but also in terms of energy per unit volume of its electric field.

Kirchhoff's rules, as basic concepts, rather than as techniques for the solution of networks. Such circuits as the potentiometer and the Wheatstone bridge as illustrations for the application of the ideas represented by Kirchhoff's rules.

The magnetic field, as a consequence or manifestation of the motion of electric charges in general. Ampere's Law as the basic statement (preferably in the form of the vector cross-product) of the magnitude and direction of the magnetic field related to moving charges as individual entities and as an electric current.

The magnetic field, in terms of the force on a charge moving therein (the Lorentz force) and likewise in terms of the force on a current carrying conductor in the magnetic field. Illustrative examples and problems from a variety of devices with the emphasis always on the fundamental laws rather than the utility or detailed operating characteristics of the devices.

Induced e.m.f., "motional" from the standpoint of the Lorentz force, as well as the more general situation expressed by Faraday's Law. The property of inductance as a consequence of Faraday's Law.

The general properties of idealized magnetic materials and some of the qualitative aspects of ferromagnetism, mostly as illustrated by the hysteresis loop. Ampere's circuital relation as a line integral embracing the magnetizing current in such simple cases as the toroid with and without an air-gap. In this connection, once again the concept of stored energy, this time in the magnetic field.

Simple circuits with inductance, capacitance, and resistance, and the simplest relationships in alternating currents.

Essential Points Concerning Upper Division Courses

Upper-Division courses should be based on, emphasize, and re-emphasize the physical principles of electricity and magnetism introduced in lower division work. Additively, the perimeter of mathematical knowledge and the appreciation of its value in electrical engineering should be expanded as demanded by: (i) those portions of the developing domain of physi-

cal science, which must be incorporated into a viable engineering curriculum, and (ii) the engineering applications thereof.

This desired expansion of mathematical knowledge could be given in a single systematic mathematical course or by inclusion in engineering courses as dictated by local conditions. Thus, Fourier series could be developed as needed for solution of periodic nonsinusoidal circuit problems, Laplace and Fourier transforms as needed for the solution of transient problems, conformal mapping as needed for static electric and magnetic field problems, vector analysis as needed for electromagnetic field theory; etc.

Work in upper-division electromagnetic theory ought to be expanded to include study of phenomena associated with other than strictly linear isotropic media to which current instruction is generally limited. In such connection it is desirable to include in the engineering curriculum a core content of the physics of matter from the modern point of view. This gives rise to the requirement for a book on solid state physics specifically directed to the needs and professional interests of the engineer.

Modern Physics and Properties of Matter

Physics seeks to understand nature; engineering seeks to utilize nature. However, in order to utilize nature properly one must also understand nature. Prior to about 1900, the electrical engineer was limited in his efforts to understand and control nature by the fact that the treatment of electric and magnetic phenomena had not advanced beyond the stage of the macroscopic methods of Maxwell. Since 1900 the development of modern physics including quantum theory, the theory of the solid state, nuclear physics and high energy physics, has provided a much broader base for the consideration of these phenomena. This new knowledge, in combination with the classical principles of electromagnetic theory, has permitted the engineer to create the new devices and components which have made possible recent developments in communication and automation. Thus the engineering student today must have an understanding of this new knowledge on the properties of matter, in order that he may contribute creatively to the technology of tomorrow and in order that he may improve the operation of present day devices by extending their frequency of operation, increasing their reliability, and providing for further miniaturization.

It is recommended, therefore, that in order to meet a real need brought about by developments of the last 50 years and to anticipate the developments of the next 50 years, the salient points of modern physics should be presented in a course to electrical engineering students as early as possible in their curriculum. It is believed by the committee that this course can be the same for all engineers and should be offered in addition to a course in general physics. The course content recommended in the report of the closed conference on nuclear physics in engineering education meets with the approval of this committee. This is as follows:

a. Atomic Structure of Matter
   Kinetic Theory
b. Fundamental Particles
c. Quantum Theory of Light
d. Atomic Structure
   1 Energy Levels
   2 Spectroscopy
   3 Periodic System
e. X-Rays
f. Wave Nature of Matter
   One dimensional wave equation
g. Atomic Nucleus
h. Molecular Structure
   Valence Bonds
i. Nuclear Structure—Elements, isotopes, elementary particles
j. Binding Forces
k. Binding Energy Curve
   1 Mass-Energy Curve
   2 Radioactivity
   3 Nuclear Reactions
   4 Fission, Fusion

1. Neutron Chain Reaction
   1 Heat—Power
   2 Radiation—Interaction with matter
     Radioisotopes
     Breeding
   3 Fission Products

It is further recommended that a course in the physical properties of matter should be available for election by electrical engineering students and that this course should present a phenomenological basis for understanding the characteristics of materials used in electrical engineering. Such a course might include the topics suggested by the Allerton Conference on Solid State Physics in Engineering, namely:

Crystal Structure
Binding Forces and Crystal Types
Mechanical and Thermal Properties
Electrical Conductivity
  (a) Metals
  (b) Semiconductors
  (c) Salts
Dielectric Properties
Magnetic Properties
Surface Effects
Prosphors and Photoconductivity

Modern Applications in Traditional Engineering Courses

In addition to strengthening the scientific foundation of engineering by the inclusion of "Modern" physics courses, it is important to point out applications in modern physics by illustrative material and problems introduced into pertinent existing courses in each of the conventional branches of engineering. This would include problems posed by the newer industries within the conventional engineering disciplines and the newer techniques which can now be applied in older industries.

As an illustration of the applications of nuclear physics in the field of electrical engineering, instrumentation studies may be considered. These should include the detection of the various nuclear radiations over a wide range of intensities, and as a part of the control system of a nuclear power reactor. This becomes a good example of a servomechanism. The radioactive thickness guage is a corresponding example of how a new technique can be applied as a process control in the older paper industry.

Need for Experimentation in Curricula

This conference, recognizing the many pressures for change in Electrical Engineering curricula, makes explicit its wish that no action taken by it shall be interpreted as discouraging experimentation by the universities in altering the content of courses, or in changing the location of courses within departments.

Cooperation to Meet Local Situations

The conference recognizes that the jurisdictions for the various functions implied in its recommendations must vary from one institution to another as indicated by local conditions. It strongly urges sustained contacts between the departments of physics and electrical engineering in each institution by such means as frequent conferences and exchanges of teachers and personnel on research projects. The understanding gained by such contacts should make it possible for faculties to develop optimum engineering programs with their local facilities.

Conference Members

L. V. Bewley, Lehigh University; W. B. Boast, Iowa State College; J. C. Boyce, Argonne National Laboratory; J. G. Brainerd, University of Pennsylvania; T. B. Brown, George Washington University; H. E. Hartig, University of Minnesota; V. P. Hessler, University of Illinois; G. H. Hickox, National Science Foundation; T. J. Higgins, University of Wisconsin; C. L. Hogan, Harvard University; J. H. Howey, Georgia Institute of Technology; V. A. Johnson, Purdue University; E. C. Jordan, University of Illinois; J. J. Karakash, Lehigh Univer-

sity; J. H. Lampe, North Carolina State College; W. A. Lewis, Illinois Institute of Technology; D. P. Mitchell, Columbia University; F. E. Myers, Lehigh University; A. O. Nier, University of Minnesota; L. O. Olsen, Case Institute of Technology; H. A. Peterson, University of Wisconsin; J. G. Potter, Agricultural and Mechanical College of Texas; E. Rogers, University of Alabama; E. R. Schatz, Carnegie Institute of Technology; W. M. Schwarz, Union College; R. J. Seeger, National Science Foundation; H. Semat, City College of New York; J. N. Thurston, Clemson Agriculture College; J. H. Van Vleck, Harvard University; H. W. Welch, Jr., University of Michigan; M. W. White, Pennsylvania State University; D. Williams, Ohio State University; J. Zaborszky, Missouri School of Mines and Metallurgy.

Conference Co-Secretaries,
J. G. POTTER
L. O. OLSEN

Thermodynamics in Engineering Education Conference

The Pennsylvania State University
June 27, 28, 29, 1955

A conference for thermodynamics teachers concerning certain aspects of thermodynamics, which are having an impact on engineering and engineering education, will follow the American Society for Engineering Education annual meeting at The Pennsylvania State University. Sponsored by the National Science Foundation and the American Society for Engineering Education, this conference continues the study of basic sciences in engineering. The program will include the following subjects:

1. Special industrial applications of thermodynamics.
2. All engineers need thermodynamics.
3. Thermodynamics and irreversible processes.
4. Irreversible coupled flows.
5. Electric and magnetic phenomena.
6. Electrochemistry.
7. Statistical thermodynamics.
8. Rate processes.
9. Relaxation phenomena.
10. Elastomer thermodynamics.

Further details about conference arrangements and the program can be obtained from Professor W. E. Ranz, Department of Engineering Research, The Pennsylvania State University, University Park, Pennsylvania. Registration is limited.

Physics in Engineering Education*

The National Science Foundation has granted the American Institute of Physics the sum of $13,600 to support a study and evaluation of the role of physics in engineering education. A committee to make the study has been appointed by the Institute as follows:

E. Hutchisson, Case Institute of Technology (*Chairman*)
L. B. Borst, New York University (*Secretary*)
J. W. Buchta, University of Minnesota
Dudley Chambers, General Electric Company
Hugh Dryden, National Advisory Committee for Aeronautics
Harvey Fletcher, Brigham Young University
W. V. Houston, Rice Institute
J. A. Hutcheson, Westinghouse Electric Corporation
R. B. Lindsay, Brown University
D. H. Loughridge, Northwestern University
H. V. Nehr, California Institute of Technology
Lloyd P. Smith, Cornell University
J. A. Stratton, Massachusetts Institute of Technology
William W. Watson, Yale University
Marsh W. White, Pennsylvania State University

The role of physics in engineering education has continually been under discussion. Recently such discussion has been intensified and has received the attention of a committee of the American Society for Engineering Education. The committee was asked to determine the patterns that engineering education should take to keep pace with the rapid developments in science and technology, and to educate men who will be competent to serve the needs of and provide the leadership for the engineering profession over the next quarter-century. It has now prepared and circulated an interim report including recommendations.

Another committee, sponsored by the American Association of Physics Teachers, has also considered this subject and wishes to develop well-founded views to exchange with the ASEE committee. The present AIP activity was undertaken at the request of the AAPT because it was believed that the interest and resources of the entire organization of physicists should be mobilized behind this enterprise.

A meeting of the AIP committee was held at Gould House of New York University on January 31 and February 1. As a result of a program adopted at this meeting, visits will be made to a number of institutions having engineering schools to determine the actual present role of physics in the engineering curricula and the objectives in the minds of those who teach it. The information and opinions gathered in this way will be digested and interpreted by the committee and its staff, and then presented in a report with recommendations. An opportunity to present an interim report will come at the joint ASEE-AAPT meeting June 20–24 at Pennsylvania State University.

* Reprinted from *Physics Today*, March, 1955.

Conference on Thermodynamics in Engineering Education

The following persons participated in the Conference on Thermodynamics in Engineering Education at Purdue University, Lafayette, Indiana, February 28 and March 1, 1955:

1. J. F. Bailey, University of Tennessee; 2. F. G. Brickwedde, U. S. Bureau of Standards and University of Maryland; 3. W. L. Collins, University of Illinois; 4. C. E. Cutts, National Science Foundation; 5. B. F. Dodge, Yale University; 6. W. C. Dunlap, General Electric Co.; 7. R. E. Fadum, North Carolina State College; 8. R. G. Folsom, University of Michigan; 9. N. A. Hall, University of Minnesota; 10. J. Halpern, University of British Columbia; 11. G. A. Hawkins, Purdue University; 12 G. H. Hickox, National Science Foundation; 13. J. H. Keenan, Massachusetts Institute of Technology; 14. R. A. Morgen, Purdue University; 15. R. W. Moulton, University of Washington; 16. E. F. Obert, Northwestern University; 17. W. E. Ranz, Pennsylvania State University; 18. W. Ross, Pennsylvania State University; 19. F. D. Rossini, Carnegie Institute of Technology; 20. I. W. Smith, University of Toronto; 21. J. M. Smith, Purdue University; 22. M. Tribus, University of California; 23. E. Walker, Pennsylvania State University; 24. M. W. Zemansky, City College of New York.

The relationship of thermodynamic courses to physics was discussed as well as the general status of thermodynamics teaching. As a result of these discussions the conference adopted the following resolutions:

1. Thermodynamics is a fundamental science which is a desirable element in the general and professional education of all engineers.

2. Although instruction of engineering students in thermodynamics is relatively highly developed, the attention of teachers of thermodynamics should be directed toward the newer areas of activity, such as irreversible thermodynamics and statistical thermodynamics.

Then the following decisions were made concerning the aims, objectives, and methods for conducting the forthcoming conference:

1. The open Thermodynamics Conference at The Pennsylvania State University should be aimed at young teachers of engineering thermodynamics.

2. Some of the material to be presented should illustrate the use of thermodynamics by industry and practicing engineers.

3. A discussion should be included to cover present practices in the teaching of mechanical and chemical engineering thermodynamics and trends.

4. The role of thermodynamics in curricula other than chemical and mechanical engineering should be presented.

5. The subject of heat transmission should be excluded from the conference program.

6. The subject of teaching methods and teaching aids should be excluded from the conference program, since this is the subject of one of the sessions of the 1955 ASEE annual meeting.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 29–30, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 7, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Swarthmore College	May 7, 1955	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	March 26, 1955	M. M. Jones, University of Missouri
*National Capital Area			J. C. Michalowicz, Catholic University
*New England			E. R. McKee, University of Vermont
*North Midwest			C. J. Pratt, Michigan College of M. and T.
*Ohio			K. F. Sibila, University of Akron
	University of Akron	May 7, 1955	
Pacific Northwest	University of Idaho	April 15–16, 1955	M. L. Jackson, University of Idaho
*Pacific Southwest			B. M. Green, Stanford University
Rocky Mountain	Colorado A. & M. College	April 16, 1955	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9, 1955	V. L. Doughtie, University of Texas
*Upper New York			B. H. Norem, Syracuse University

Members of the Society are welcome at all Section Meetings

* No date set.

THE T-SQUARE PAGE

CONTRIBUTIONS TO ENGINEERING EDUCATION
BY THE
DIVISION OF ENGINEERING DRAWING

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University of Nebraska

HAROLD P. SKAMSER, *Secretary-Treasurer*
Michigan State College

WILLIAM E. STREET, *Vice Chairman*
A & M College of Texas

IRWIN WLADAVER, *Editor of*
the T-Square Page
New York University

Teaching Engineering Graphics Effectively for Today and Tomorrow *

By FRANK A. HEACOCK

Professor of Graphics, Princeton University

In our engineering colleges every student must learn the fundamental principles and useful applications of mathematics, chemistry, physics, mechanics, and engineering graphics. The comprehensive term "engineering graphics" includes not only the basic courses in engineering drawing and descriptive geometry but also the advanced graphics courses and important parts of other engineering courses that may be taught most effectively when graphic methods are employed. It is the purpose of this paper to point out the educational objectives of graphics instruction and to show in some detail how engineering graphics may be taught effectively to accomplish these objectives so that the engineering student will derive from it all of the benefits that are of value to him while he is in college and after he enters his profession.

Let us consider the student, the time available, the subjects taught, the instructor, and the problems involved in upgrading our courses. The student is our most important consideration, and his educational development demands our careful thought. How shall we make the best possible use of the limited teaching time available? Although the course content of engineering drawing and descriptive geometry is similar in most colleges it does not conform to a standard pattern. These basic courses are being continually improved and new material is being added to keep pace with engineering developments. The instructor who is aware of current trends in his field and who is willing to change traditional teaching methods when a better procedure is found for developing the creative capabilities of the individual, will gain the interest and full cooperation of his students. In this paper I endeavor to bring into proper perspective these significant aspects of the graphics instruction picture.

Engineering drawing is the universal medium of expression for showing exactly how things are to be manufactured or built, or accomplished in the industrial

* Presented at ASEE Annual Meeting, University of Illinois, June 1954.

world. For best results each drawing must tell its story clearly and completely. Therefore, engineering drawing is taught as a precise, graphic language which all engineers must learn to write and to read. A college course in engineering drawing has important educational values in addition to the production of satisfactory drawings. We should consider technical sketching, reading drawings, fitting the course to the students' ability, the true meaning of skill, and the best way to budget the teaching time available.

Facility in technical sketching is regarded as an essential part of the engineer's working equipment, and it is our job to teach the student how to make quick, effective sketches. Requiring no special talent, the ability to make good sketches is the result of careful, persistent practice under the guidance and encouragement of the drawing instructor. Experience has shown that students make rapid progress in learning the principles of projection drawing while making multiview sketches of simple machine parts on cross-section paper at the beginning of the course. The sketch introduces the student to a natural way of expressing on paper his mental image of the object when it is viewed from above, from in front, or from the side. As it provides a convenient means of portraying his constructive thoughts, the sketch promotes the habit of exact thinking, careful observation, and correct mental vision. The student finds his ability to sketch a useful aid to learning not only in the drawing course but also in mathematics and physics. The importance of technical sketching requires greater emphasis on freehand work throughout the course in engineering drawing.

Learning to read drawings is just as important as learning how to draw. To interpret an engineering drawing and form in the mind a correct, complete picture of the object represented is a stimulating exercise in constructive thinking. It involves accurate observation, progressive visualization, and a thorough mental grasp of each detail in its true relation to other details and to the whole object. A multiview drawing cannot be read by looking at one view. The student must imagine himself moving around the actual object and looking at it in the direction each view is taken. This nimble mental shift from one viewpoint to another excites the imagination. The new facts discovered at each viewpoint build up the mental picture until it becomes a complete realization. Many carefully selected exercises of progressive difficulty are needed to develop facility in reading drawings. Useful for this purpose are completion problems that require a new view of an object in proper relation to the given views. Other good exercises include the missing line problem and the possible view problem. The combination of reading exercises and technical sketching is especially helpful in frequent quizzes throughout the drawing course.

In our search for better ways to teach engineering drawing we must be sure to fit the course to the needs and capabilities of the student. Although it would be helpful to count on effective drawing instruction in high school, many of us have learned from experience that it is best to start at the beginning and not to assume that the student who made drawings in high school has a good working knowledge of the fundamental principles of projection drawing. In an average class of 25 freshmen most of them respond quite readily to instruction and make encouraging progress. A few students do exceptional work, producing drawings that may be displayed as examples of superior drafting. On the other hand, there may be one or two who simply cannot learn to draw. After slow and clumsy effort, their completed drawings are usually not acceptable, and they make a poor showing on tests and examination. We sometimes wonder how they managed to pass the engineering aptitude test. This wide range of natural ability makes it difficult to set a proper pace for the class. The individual who is capable of rapid prog-

ress and who has acquired a certain proficiency in drawing should not be held back or allowed to mark time. The remedy suggested for this situation is to section students according to ability in order to set a proper pace for each group and to allow each individual to develop to his highest level of creative thought and skill in graphic expression.

In the Preliminary Report of the ASEE Committee on Evaluation of Engineering Education the statement is made in reference to engineering drawing that "its value as a skill alone does not justify its inclusion in a curriculum." I doubt that any college course in engineering drawing has either the time or the intention to develop manual expertness in drafting. But skill in a broader sense is a worthwhile objective of the drawing course. The true meaning of skill is the ability to use one's knowledge effectively. Engineering drawing provides a systematic procedure for organizing productive ideas and expressing them on paper in an accurate, unmistakable manner. This graphic habit of thought and expression which the drawing course aims to develop is a valuable skill that the engineering student will often use to advantage.

Time-Saving Methods

In many colleges the time allotted to engineering drawing has been reduced to the point where it is difficult to cover essential material and teach the course effectively. In trying to budget the limited time available one is forced to consider time-saving methods of instruction. Workbooks of printed problem sheets have been widely adopted, in spite of their limitations, because they allow the student to cover two or three times as many problems during the course. Another way to save time is to reduce the number of problems and eliminate repetition by selecting problems that combine several features of instructional value to the student.

More efficient use of time could be gained by teaching the principles of dimensioning along with shape description from the beginning of the course. A multiview drawing without dimensions is like a bird without wings. After the principles and methods of simple dimensioning are applied to elementary problems, the special practices and notes referring to typical shop operations can be gradually introduced when appropriate problems are assigned. Experience has shown that this parallel treatment of shape and size description saves time and gives good results. In some large industries there is a definite trend toward simplified drawing and dimensioning practices which could well be reflected in drawing courses by the gradual adoption of sound methods for eliminating nonessentials and needless repetition of details. This would also save much valuable time on the drawing board.

Turning now to descriptive geometry, we find this basic engineering course under fire by those who do not appreciate its educational values. At some colleges having ROTC programs students are allowed to drop descriptive geometry to make room for a required military, naval, or air science course. In a few schools department heads who do not consider that descriptive geometry is necessary in their field of engineering have omitted the course from their curriculum. In view of this situation and its implications for the future, let us reappraise our objectives, plan the best possible use of our potential resources, and chart a sane course into the probable developments that lie ahead. In my judgment there is a significant trend away from the representational and disciplinary phases of descriptive geometry and toward its versatile applications as an analytical tool through the full utilization of vectors, graphs, and diagrams. As the foundation of graphical science it can be developed into a cogent force for good in engineering education.

At the beginning of the course our chief concern is to give each student a thorough

grounding in the fundamental principles of descriptive geometry. These principles and methods are easy to grasp and to apply. The common sense approach of the auxiliary view method appeals to the practical mind of the engineering student. This novel method of attack arouses his interest because it opens up an entirely new line of thought that is in itself most valuable. The importance of the strategic direction of sight and the clever use of the end view of a line and the edge view of a plane capture his imagination. He is impressed by the geometric validity of a graphic solution that checks itself. When explained in proper sequence it is easy to establish the sound principles of descriptive geometry.

The only effective way to learn descriptive geometry is to work out diligently on the drawing board a series of carefully selected problems that embody all of the essential principles. Students often make the mistake of trying to memorize the mechanical operations of the graphic solution without thinking the problem through beforehand. A special effort should be made to encourage correct study methods and to ensure individual work on problem solutions.

For many years increasing emphasis has been given the useful engineering applications of descriptive geometry. One of its early uses was stereotomy, which is the science of stone cutting for arches, domes, and cloisters. Later applications included the graphic solution of problems encountered in structural steel details of hip and valley roofs and skew bridges, geology and mining problems, intersection and development problems in sheet metal structures such as penstocks and draft tubes, air conditioning ducts and ventilating systems, and lofting of surfaces for ships and aircraft. A wide variety of useful applications of descriptive geometry enriches the course, promotes student interest, and makes the teaching more effective.

As engineering drawing and descriptive geometry are closely related and each helps the other, sixteen engineering colleges have found it desirable to combine them in a single basic course which might be called engineering graphics. In order to do more work in less time and teach all of the essential material more effectively the two subjects should be securely joined together to preserve continuity and unity of purpose. The common bond of orthographic projection which is the sound basis of both subjects permits consolidation and a substantial saving of time. Judicious rearrangement of course content produces further economies by avoiding overlapping of topics and needless repetition. Some drawing courses contain problems involving intersection and development which properly belong in the descriptive geometry part of the course. Also certain parts of pictorial representation may be presented to better advantage as applications of descriptive geometry. A true dovetailing of the various elements of the two subjects must be achieved by efficient reorganization of essential material in a logical sequence so that each new phase is properly correlated with preceding principles and methods. Real integration of engineering drawing and descriptive geometry in an effective basic course in engineering graphics appeals to a good many forward looking teachers in our field.

Engineering students must acquire a working knowledge of vectors because the vector principle is widely used in engineering. Vector analysis is a branch of mathematics, but the graphic approach is often preferred. Whenever vector problems involve three dimensions, the methods of descriptive geometry are used to advantage. Therefore, a basic course in engineering graphics should include adequate treatment of vector geometry. This should not be limited to concurrent forces or static conditions, but contain problems dealing with motion, time, velocity, acceleration, and couples due to nonconcurrent forces. The required courses in mathematics, physics, and mechanics which the engineering student is

taking at the same time, or will soon start, now put greater emphasis on vectors and their manifold applications. Thus the graphic solution of vector problems provides a convenient means of coordinating descriptive geometry with other courses in the engineering curriculum. This graphic approach clarifies many difficult problems that the student encounters in other courses and it gives him a better grasp of basic relationships. Consequently, it enhances his opinion of the value of graphics training as a dependable aid to the learning process.

Graphics As An Analytical Tool

Descriptive geometry provides an excellent introduction to the study of graphics as an analytical tool. Based on logical reasoning and the sound principles of space geometry, it puts into practice the engineer's methods of thinking each problem through to a successful and accurate solution on the drawing board. It teaches the student how to size up a problem from any desired angle and to consider possible methods of attack. After weighing the advantages and shortcomings of each method for solving the problem, he is able to use good judgment in selecting the best procedure. The continued use of graphic methods as a companion to analytical thought imparts self-reliance, resourcefulness, and initiative. Thus the study of descriptive geometry helps the student develop the keen, practical insight that is essential to advanced work in graphic analysis.

Many colleges have courses in advanced engineering drawing which are required for students in certain branches of engineering. In these courses the principles of projection drawing and dimensioning are applied to planning, sketching, and production of working drawings that conform to accepted standards of good practice in industry. As an understanding of shop operations is essential, lectures, demonstrations, and visits to the shops usually supplement individual instruction in the drafting room. In most cases the course content is adapted to suit the specific needs of students enrolled in the different departments of engineering. This setting offers a favorable opportunity to introduce various drawing projects involving some empirical design, which will challenge the ability of the engineering student. Here also is a good place to teach the principles and methods of representing facts, figures, trends, and performance by means of graphic charts. It is essential that the engineering student gain a working knowledge of this important means of recording and communicating information through actual design and construction of both technical and popular charts.

Advanced graphics is usually taught in an elective course at the junior or senior level. This course provides instruction and practice in graphical analysis of advanced problems and graphic methods of computation. The subjects covered may include graphical mathematics, graphic methods of determining empirical equations from experimental data, application of vectors to a wide range of force and motion problems, and design and construction of nomographs and other calculating charts. Many colleges have a senior level course in engineering analysis that is designed to help the student set up an engineering problem so that it can be solved by calculus. Sometimes the mathematics is so involved that the student has difficulty in grasping the method of solution, and the graphic approach is used to clarify the procedure. Here is an opportunity to assist the student when he needs the kind of aid the graphic methods provide. Let us devote our best efforts to organize and teach the level courses in advanced graphics that will be most effective in developing the creative talent of the engineering student to its highest capability.

Occasionally a colleague who is teaching a junior or senior course complains that a few students in his class do careless drafting, or make faulty sketches

or show scant knowledge of graphic methods. When we check back we find that the same students did creditable work in the drawing course. Unfortunately some individuals stop trying when quality standards are relaxed. This emphasizes the need for full cooperation by all faculty members in insisting upon high quality work whenever student drawings, sketches, or graphs are required in their courses, because employers of our engineering graduates demand it. For best results in this direction we should do some helpful missionary work among our colleagues.

This leads to another worthwhile purpose. If we convince a teacher of the value of the graphic solution for clarifying a difficult problem and for checking the result obtained by the usual mathematical solution, he will give the graphic method a trial in his course. Naturally the graphic procedure must be properly explained at the blackboard and the student must be required to work out an accurate graphic solution on the drawing board. Then the graphic method will sell itself to teacher and student because of its inherent advantages. As the graphic approach proves its educational value its use will spread to other technical courses to strengthen the role of graphics in engineering education.

Opportunities in Research

There are many opportunities for the teacher of engineering drawing and descriptive geometry to apply his talents to the solution of problems that arise in research projects in science and engineering. Many of us would like to undertake a graphics research assignment and we ask only a proper introduction to this purposeful effort. One can make a useful start by acting as advisor to graduate students who are working on thesis projects and by assisting colleagues who are engaged in research. This experience in setting up research problems and solving them by graphic methods often leads to the discovery of unsolved problems that challenge our best efforts. Let me urge you to engage in fundamental research. Your Committee on Advanced Graphics is willing to offer suggestions and assistance if desired. Many research projects in engineering and science need your proficiency in applying graphic methods to their problems. In return this rewarding experience will make your teaching of engineering graphics more effective for today and tomorrow.

CANDID COMMENTS

Student-Centered Review, and Rationalized Exams

By ROBERT B. DAVIS

Assistant Professor of Mathematics, University of New Hampshire

1. "Non-Directive" Review

In several of my calculus sections I have found myself with a couple of weeks free time at the end of the semester. The natural use for this free time was to spend it reviewing for the final examination, and we did this, using a rather definitely "student-centered" or "non-directive" approach—that is to say, the instructor did *not* run the show. After suggesting a review, the instructor sat back and let the class decide what to do next. Class response was eminently satisfactory, and a reasonably organized procedure quickly evolved. Students selected problems, volunteers went to the board and solved the problems with the assistance of the rest of the class—and the instructor sat in silence and watched. Class interest and participation were unusually high—aided, no doubt, by considerable relevant and good-natured heckling from the audience. The value of this kind of approach seemed considerable.

There has been a good deal of interest in introducing such a "student-centered" approach more widely in engineering education. (This is often called by other names, such as "non-directive," "group dynamic," or "permissive." I am not trying to make any sharp distinctions of language here.) We might cite the various items in the bibliography, in this connection.

However, many faculty members have considered the matter, and have felt reluctant to trust in a method which appears to leave so much to chance, and appears to frustrate the students' frequent desires to be dependent, or to be told just what is expected of them—or even to get as much help as they would like. Some have felt that the demands on the students' maturity are excessive (not to mention the demands on the instructor's self-control).

Leaving a free space in the schedule for two weeks of non-directive review preceding final exams may offer a means of overcoming some of these objections. At this time student motivation is unusually high. The class members know one another and know the instructor. Also, they have considerable familiarity with the subject matter by then. The circumstances seem unusually favorable for a group-dynamic approach. This is, in fact, the period when the student should be organizing his knowledge in his own mind, and should become especially active in contrast to his earlier passive dependence upon the instructor's efforts at organization.

Does this point toward a possible extension of non-directive methods?

2. A Rationalized Examination Progra

There is a second point that has recently come to my attention.

As I have looked over various examination procedures, I have been struck by the rather basic errors that are frequently made in setting and grading exams. Basic errors, that is to say, in the sense of precise scientific measurement. Some schools give failing grades to many students who do not appear to deserve them—if, indeed, anyone ever does "deserve" the

These errors are familiar in economics as double counting, in statistics as neglecting higher moments of distributions and failure to note trends, in physics as problems in quantization, and as stability of data, and in mathematics as non-linear scale shifts and as the addition of unlike units—adding apples to bananas. We set an exam in which five points in one problem are very hard to get, whereas thirty points in another come quite easily. These points have quite different meaning. Nonetheless, we add them all together and consider only the sum. In doing this we neglect the fact that a certain item—not necessarily important in general—may have appeared in three or four different problems and may have been counted far more than was consciously intended. We average together a sequence of exam grades, and all too frequently make no allowance for the difference between what a student knows in June, and what he knew last March. We then interpret this on a highly non-linear scale, where the first sixty points don't count for much individually, but one or two points from 60 on up may make a lot of difference. Then we quantize this into letter grades, where 70 equals 79, but 79 is not nearly equal to 80. In all of this process we customarily wreck havoc with the ordinary notions of significant figures. I have often seen students failed on the basis of 10 points out of 800, which seems to me to be an insanely optimistic view of the accuracy of tests as measuring instruments.

In all of this our basic philosophy seems to be that, if only we average together *enough* irrelevant data, at some point it becomes not only relevant but surprisingly precise.

The question is, can we do any better? I say yes, as a matter of fact, we can. We can make a direct relation between what the student does and what we want to ask of him. Specifically, we can determine a set of techniques, concepts, etc., which we consider the minimum. If the student shows reasonable mastery of this material, then we agree to take him along into the next term's work, and we guarantee him at least a passing grade. In a first term calculus course, for example, this might conceivably be a few fairly simple differentiation problems, and perhaps one or two easy word problems. In any event, I am skeptical of the value of requiring students to repeat a term's work, and it seems to me that this minimum material should be kept at a fairly simple level, with liberal allowances for minor numerical mistakes.

Similarly we can add several sets of progressively more difficult material, to determine which students should get C's, B's, or A's. But in no event do we add up total scores, for we do not want a brilliant piece of work on a difficult example to be obscured by a minor numerical error in one of the trivial problems. If a student can do most of the A material, he gets an A. In this way, each letter grade achieves a qualitative meaning; a B, for example, means that the student can handle the fairly difficult parts of the course, but not the most difficult ones. This seems to me a considerable improvement over the vague meaning which a B tends to have at present, compounded as it is of a long string of doubtful arithmetic operations, which assuredly are not even commutative.

Of course, the question of grades, and of failing students, goes much deeper than this. I suspect we should rely a good deal more on the instructor's judgment than most schools are willing to. Doubtless we shall someday have a more helpful treatment for failing students than our usual technique of intimidating them, implying to them that they personally are not up to standard, and requiring them to repeat the term's work. But I offer this grading procedure as an interim measure. It would work far less injustice than the unreasonably rigid (and irrational) systems still widely used at present.

We certainly need to learn to think in broader and more fundamental terms. Nonetheless, grades—and especially failing grades—are deeply interrelated with important basic issues. As a further example, I might note that excessive penalties for minor errors may so cancel excellent work elsewhere on an exam that it sometimes becomes nearly impossible for a student to earn a grade of A. This can speedily create an atmosphere of fatalism or resignation, and the atmosphere or general attitude among the student body is one of the most basic matters in any university.

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Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

EAST ASSISTANT PROFESSOR OF Metallurgical Engineering desired for September, 1955, with emphasis on heat transfer, thermodynamics, and physical chemistry. Advanced degree essential, experience desirable. May-1.

CHEMICAL ENGINEER TO HEAD Chemical Engineering Department of Young Four Year State College, Doctorate Essential. Salary for twelve months. Open. Address Dean, Lamar State College, Beaumont, Texas.

INSTRUCTOR OR ASSISTANT PROFESsor to teach engineering drawing and descriptive geometry. Engineering degree and teaching experience desired. Opportunity to do graduate work. Rank and salary dependent on education and experience. Appointment beginning September 15, 1955. Write J. D. McFarland, Chairman, Department of Drawing, The University of Texas.

CHAIRMAN OF CHEMICAL ENGIneering Department in accredited Eastern college; to administer undergraduate program and organize graduate program. Ph.D. preferred. Give teaching, research and industrial experience. Must be available for September, 1955. May-2.

POSITION OPEN TO TEACH DRAWING and Mechanics, Dept. of Engineering Mechanics, University of Nebraska. Rank and salary based on applicants' qualifications. Write inquiries to E. J. Marmo, Chairman of Dept., Lincoln, Nebraska.

INSTRUCTOR IN ELECTRICAL ENGIneering beginning September 1, 1955. One interested in teaching fundamental electrical engineering subjects. Salary depends on qualifications. Opportunity for advancement. New building and equipment. Apply to, Chairman, Department of Electrical Engineering, University of Nebraska, Lincoln 8, Nebraska.

ASSISTANT PROFESSOR, COMMUNIcations, Electronics. Real opportunity for young Ph.D. interested in both teaching and research. Rapid advancement possible for man with initiative and ability. Write: Chairman, Division of Engineering, Brown University, Providence 12, R. I.

TEACHING POSITIONS OPEN IN FOLlowing Fields: Electrical Technology: Mechanical Technology; Construction Technology. Must have B.S. degree in specific field, industrial experience in field desirable. Salary ranges: Junior Instructor $4080.00 to $4680.00; Instructor $4800.00 to $6000.00, starting level dependent upon education and experience. Applicants must be qualified to teach major and related subjects. Hudson Valley Technical Institute, Troy, N. Y. (Unit of The State University of New York).

CHEMICAL ENGINEER FOR HEAD OF Chem. Engrg. Department and Director of Research in accredited Engineering College. Must have doctor's degree. Research and teaching experience essential. Metropolitan New York. Appointment effective September, 1955. May-3.

ASSISTANT PROFESSOR OF ENGINEERING Mechanics open September, 1955. Doctor's degree with major in mechanics, or fluids, and with a strong minor in applied mathematics desired. Teaching experience and publications important. Younger man with Master's degree desiring opportunity for advanced study may be considered at the Instructor level. Apply to Prof. G. N. Cox, Chairman, Department of Engineering Mechanics, New York University, New York 53, N. Y.

ENGINEERING TEACHING POSITIONS in the Civil and Electrical fields are available at Fresno State College. Young men are preferred. Instructor and Assistant Professor positions open. Entire new campus under construction, including engineering. Excellent salary scale. Apply Dean A. R. Lang, Fresno State College, Fresno, California.

INSTRUCTOR—FOR DRAWING, FRESHmen Engineering Problems, Mechanics. Branch immaterial. Beginning in September. Salary determined by qualifications. Nine months per year. Apply to Dean of Engineering, Colorado A & M College, Fort Collins, Colorado.

INSTRUCTOR IN GENERAL ENGINeering, to teach engineering drawing and descriptive geometry. Engineering degree required. Appointment to begin Sept. 1, 1955. Send application to: C. I. Carlson, University of Illinois, Rm. 147, Navy Pier, Chicago 11, Illinois.

PROFESSORIAL POSITION OPEN ON the faculty of the Department of Electrical Engineering of Northwestern University. Faculty rank and salary will be determined upon the qualifications of the applicant selected. Position starts in September, 1955. A Ph.D. degree is desirable, but not necessary, if the applicant has a sufficiently strong research and publication record. May-4.

OPENINGS IN THE COLLEGE OF ENgineering of West Virginia University Beginning September 1955: AERONAUTICAL ENGINEERING: *Associate Professor* to teach aerodynamics. Ph.D. is required. Salary $6000 for nine month school year. CIVIL ENGINEERING: *Associate Professor* to teach undergraduate and graduate courses in structural design, intermediate structures, reinforced concrete and foundations. Ph.D. and experience desired. Salary up to $6000 for nine month school year. *Instructor* to teach surveying, fluid mechanics and other undergraduate courses. Master's degree or post-graduate experience required. Salary up to $4500 for nine month school year. ELECTRICAL ENGINEERING: *Instructor* or *Assistant Professor* to teach A.C. circuits to undergraduate electrical engineering students and elementary theory to non-electrical students. M.S. degree preferred. Experience will determine rating. Salary up to $5000 for nine month school year. INDUSTRIAL ENGINEERING: *Instructor* to teach industrial organization, motion and time study, production control and engineering economy. BSIE or BSME (Industrial Option) is required. Man appointed may work towards M.S. degree. Salary $4300 for nine month school year. MECHANICAL ENGINEERING: *Instructor* to teach engineering drawing, descriptive geometry and mechanism. BSME is required. Man appointed may work towards M.S. degree. Salary $4500 for nine month school year. *Assistant Professor* to teach thermodynamics, heat engines and mechanical laboratory. MSME degree is required. Salary $5300 for nine month school year. MECHANICS DEPARTMENT: *Instructor* to teach statics, strength of materials and kinetics. B.S. degree in any accredited engineering curriculum is required. Salary $4000 for nine month school year. *Assistant Professor* to teach statics, strength of materials and kinetics. M.S. degree in any accredited engineering curriculum is required. Salary $5000 for nine month school year. Applications for these positions should be sent to Dean R. P. Davis, College of Engineering, West Virginia University, Morgantown, W. Va.

Minutes of Executive Board, Knoxville, Tennessee, April 15, 1955

A meeting of the Executive Board of the ASEE was held at Knoxville, Tennessee on April 15, 1955 at 10:00 A.M. *President* N. W. Dougherty presided. Those present were *Vice Presidents* W. L. Everitt, B. R. Teare, Jr., L. J. Lassalle and H. K. Work; *Treasurer* G. W. Farnham and *Secretary* W. Leighton Collins.

1. *Report of the Secretary*

a. A lack of satisfactory space in any of the engineering buildings at the University of Illinois resulted in the University transferring a campus residence to the College of Engineering and making it available for the Society headquarters. The offices are all located on the first floor. The University allocated $2800, in addition to the loss of rent, to adapt the space to ASEE use. The University maintains the building and grounds, but asked the ASEE to pay for the utilities. The University also will furnish space and equipment for the Editorial Secretary.

b. Most of the newly ordered furniture has been received. It matches the old and the total cost to date is about $1200.

c. The office staff consists of Mrs. Naomi Garman, Office Secretary; Mrs. Louise Chambliss, Membership Secretary; and Mrs. Dorothy Sams, typist.

d. The Executive Board *voted* approval of a utilities item on the books to take care of routine janitor service, heat, light and gas. The secretary estimated the cost would not exceed $700 per year.

e. The Secretary explained the reasons for selecting the First National Bank in Champaign as the depository for the checking account. The Executive Board *voted* approval of the selection.

f. The Secretary stated the bonding company now bonds positions and not the individuals holding them. The Executive Board *voted* approval of the bonding and the payment of a three-year premium in order to save one-half of a year's premium.

g. The Executive Board *voted* to insure the furniture and equipment but not the society records. For the protection of the latter the Executive Board *voted* approval of the purchase of a fire-resistant filing cabinet.

h. The Executive Board authorized the President to express the appreciation of ASEE to Carl Muhlenbruch and his committee for their fine work in compiling and editing the Educational Aids Manual. Mr. Muhlenbruch is requested to submit a report to the Executive Board at its June meeting covering such matters as the future work of the committee, its finances, etc.

i. It was agreed a President's News Letter should be prepared and mailed prior to the Annual Meeting.

j. The Executive Board authorized the Secretary to exceed the budgeted amount for his travel by a reasonable amount if it became necessary. It was agreed President Dougherty should represent the Society at the inauguration of former Secretary A. B. Bronwell as President of Worcester Polytechnic Institute.

k. The attendance of EUSEC guests at the Annual Meeting was discussed. Since only about four or five were planning to attend, it was agreed Vice President W. L. Everitt should contact Dean F. M. Dawson and arrange the details whereby the cost of room, board, and registration while attending the Annual Meeting would be paid for by ECAC.

2. *Report of the Treasurer*

a. The Treasurer briefly reviewed the third-quarter report and answered sev-

eral questions regarding income and expenditures.

b. The Secretary stated a revised second-quarter report accompanied the third-quarter report in order to have an agreement between the December 31st audit, accompanying the change in Secretary, and the second-quarter report.

c. The life membership fund of the constitution was discussed and it was agreed Section 4, Article II should be referred to the Constitution and By-Laws Committee for study. The Executive Board *voted* that the life membership provision of the constitution, Section 5, Article II, should be interpreted as "a total of 25 years of membership in good standing" and not a continuous period of membership of 25 years.

3. *Reports of Vice Presidents*

Vice President W. L. Everitt, ECAC, reported that the program for their General Session at the Annual Meeting was complete. A discussion of council officers led to the agreement that the officers of ECAC and ECRC need not be the official representatives of their institutions but must be members of ASEE.

Vice President H. K. Work, ECRC, used the minutes of the last meeting of the Executive Committee as the basis of his report. Major items covered were that the Review of Current Research is about ready for publication and all orders should be forwarded to ECRC; that next year's budget was being prepared and requested the Secretary to consult with former Secretary A. B. Bronwell and Dr. Renato Contini, Secretary of ECRC, regarding its preparation and the ECRC reserve fund; and that the preparation of the needed book on creativity is progressing.

Vice President L. J. Lassalle, Divisions and Committees, reported briefly and stated that he spoke on Society activities at the meeting of the Missouri-Arkansas Section.

Vice President B. R. Teare, Jr., Sections and Branches, reviewed plans for attending Section meetings. It was agreed it was desirable for members of the Executive Board to attend Section meetings and appear on the programs when requested.

4. *Report of the President*

President N. W. Dougherty reported on the program arrangements for the General Session on Tuesday morning. Dean L. E. Grinter will be on the program for about 25 to 30 minutes, following the recess, to present the Final Report on Engineering Evaluation. He will be followed by Dr. E. S. Burdell who has been allotted about 45 minutes to make a preliminary report on the Humanistic-Social Research Project.

5. *Annual Meeting*

a. The Secretary reported that there were only two conflicts with the morning General Session, one each with ECRC and ECAC.

b. The Secretary reported the final copy of the report on Engineering Evaluation should be available by May first. It was agreed the Secretary should discuss publication with Dean L. E. Grinter. It was further agreed that free copies should be distributed at Penn State; that the entire report be included in the JOURNAL OF ENGINEERING EDUCATION; and that the future selling price should be based on the cost of printing and handling.

c. The Secretary reported that the Humanistic-Social Research Project would have a short printed report available for free distribution at Penn State. The committee is handling the printing and cost is being charged to their account.

d. The Secretary raised the question of a realistic budget for the Annual Meeting. It was agreed that a budget should be submitted by the host institution and the Secretary was instructed to have Penn State submit their budget.

e. It was agreed to permit the Physics Division and AAPT to jointly sponsor an exhibit of Physics books at the Annual

Meeting if there is adequate space. The control of the exhibit is to be in the hands of the Division and AAPT and they should have a strong committee handling it. The Secretary reported AAPT to be willing to pay all expenses in connection with the exhibit.

f. It was agreed the Secretary invite Robert Roy to present the ETS project, Progress Report of Findings from Testing of Experienced Junior Engineers, at the Monday General Session.

g. (Added to agenda.) Professors L. A. Rose and J. A. Reed, the two most recent local chairmen, reported their progress in preparing the Annual Meeting Guide. They were instructed to prepare 100 copies and have them available by the time of the Annual Meeting at Penn State.

6. *ASEE-NSF and other Conferences*

a, b, c, d. The Secretary stated the reports of the closed conferences on Engineering Mechanics, Electricity and Magnetism, and Thermodynamics will appear in the forthcoming issues of the JOURNAL OF ENGINEERING EDUCATION. The same is true of the report of the joint committee of ASEE and MAA on the Teaching of Mathematics to Engineers.

e. The Secretary reported that the Evaluation Committee suggested the RWI Committee assume the problem of discussing the Evaluation report with representatives from industry and have a frank and open discussion of the report at a future meeting; it was deemed undesirable to confer with representatives of one corporation only.

f. The Secretary reported all members of the Executive Board had approved the cooperation of the Society with Lehigh University and the AISC in sponsoring the Short Course on Plastic Design in Structural Steel to be held at Lehigh University September 7–15, 1955. The ASEE has no financial responsibility, now or in the future. Lehigh had been informed of the decision.

7. *Conference on Theoretical Engineering*

The Secretary read a letter from F. C. Lindvall indicating that the drafting of a program soon would be complete. The letter was the basis for having Dean Lindvall report to the Society at its Monday afternoon General Session.

8. *Graduate Study Project*

The Secretary reported on the status of the Graduate Study Project. The Executive Board instructed the Secretary to get from the committee a well developed program and a total budget for whatever number of years the project was to cover, the program and budget then to be submitted to the Executive Board for approval. It was agreed that funds for the study should be solicited by the Society.

9. *Publication of Reports*

a. Final Report on Evaluation of Engineering Education—covered in Item 5b.

b. Preliminary Report of Humanistic-Social Research Project—covered in Item 5c.

c. Nuclear Engineering papers presented at the Northwestern University Conference—several possible procedures were discussed, an extra issue of the Journal of Engineering Education receiving the most favorable comments. It was agreed the Secretary should discuss the entire matter with the retiring and newly-appointed editors. It was believed that about 10,000 copies should be printed and that the sale price should be sufficient to cover the expense of printing and handling the extra copies. The committee is believed to have about $2000 for printing the report.

10. *Appointment of L. A. Rose*

a, b. The Executive Board *voted* that L. A. Rose of the University of Illinois be appointed Editor and Director of Public Relations, effective July 1, 1955, in accordance with the terms previously agreed upon. The Executive Board also *voted*

that advertising be handled by the Editor and Director of Public Relations. (Dean W. L. Everitt did not participate in the voting.) In addition, the Executive Board *voted* that an Editorial committee of five be appointed by the President, the Editor and Director of Public Relations being an ex-officio member of the committee. Thus, there will be an advisory committee to work with the Editor and Director of Public Relations for each aspect of his duties, editing of the JOURNAL OF ENGINEERING EDUCATION and the handling of public relations.

11. *Resolutions of Appreciation*

The Executive Board *voted* that the Secretary write to Professor C. E. Watson, retiring Assistant Secretary and Miss Marion Strohm, retiring Office Secretary, expressing the deep appreciation of the Board and the Society for their highly commendable services during their years of association with ASEE.

12. *Termination Pay*

The Executive Board *voted* to grant Miss Marion Strohm, retiring office secretary, three weeks termination pay.

13. *Social Security*

The Executive Board *voted* to pay for Social Security at such time the office staff expressed the desire for coverage.

14. *Relation of YET to ASEE at National and Local Levels*

The letter from Henry H. Armsby to A. B. Bronwell dated 13 Jan. 1955 was read and after considerable discussion it was agreed the problem be referred to the Young Engineering Teachers Committee for consideration. The discussion indicated the general belief that all YET activities should tend to pull men into the Society, that non-ASEE members could attend meetings of YET, but membership in a YET organization should require ASEE membership.

15. *Section Meeting Papers—Property of ASEE*

Vice President B. R. Teare, Jr. presented the problem and it was agreed Article 9, Section III of the Constitution should be referred to the Constitution and By-Laws Committee with the recommendation that, "shall be the property of the Society," be deleted.

16. *Committee Appointments*

a. EJC Committee on Honors for Engineers—The committee is to develop methods by which distinguished engineers may receive suitable recognition . . . and consider the establishment of awards by EJC. W. N. Jones represents ASEE.

b. U. S. National Commission for UNESCO—It was agreed the President should make appointments provided there would be no cost to the Society.

c. National Research Council—Vice President H. K. Work presented the difficulty arising from the fact that the ECRC Vice President serves for two years and the NRC appointments are for three years. It was agreed the policy should be that the ECRC Vice President be the ASEE representative to NRC and that at the end of his two year term as vice president he resign as the NRC representative.

d. Incorporation of nuclear science into engineering curricula (added to agenda) —The Secretary read the letter dated March 31, 1955 from Dean R. D. Hawkins, chairman of the Atomic Energy Education Committee. It was agreed the committee itself should make recommendations and the Secretary is to pursue the matter with Dean Hawkins.

17. *Applications for Affiliate Institutional Membership*

a, b, c. None of the three applicants had a curricula approved by ECPD but the Executive Board voted to approve membership if equivalent accreditation could be established.

It was agreed that if an institution was not eligible for membership its top officer

should be invited to join ASEE in order for the institution to receive the benefits of such membership.

17A. *Associate Institutional Memberships* (added to agenda)

The Secretary announced that by mail ballot the Executive Board *voted* to approve membership for:

American Blue Print Co., Inc.
Udylite Corporation
Continental Motors Corporation, Research Division

18. *EJC Amendments and Membership*

a, b. It was agreed to refer the application of the American Society of Refrigeration Engineers as a Constituent Society and of the American Institute of Industrial Engineers as an EJC Associate to the General Council for approval.

19. *ECPD Membership for NSPE*

It was agreed to refer the matter to the General Council for vote.

20. *Tax Exempt Status of ASEE*

It was agreed to refer the problem to the auditor, if necessary, for study and recommendation.

21. *American Council on Education Dues*

The Executive Board *voted* to pay the $200 dues for the current year.

22. *Educational Advice and Aid to Foreigners, IAESTE*

It was agreed to refer the correspondence to the International Relations Committee for appropriate study and recommendations.

23. *Dean's Conference at Cornell University*

The conference was discussed briefly without taking any action.

24. *Other Business*

a. The Secretary read the announcement of the death of Mrs. Florence Hooven.

b. The next meeting of the Executive Board will be at The Pennsylvania State University, Monday morning June 20, the exact time and place to be announced later.

c. There being no further business the meeting adjourned at 6:40 P.M.

Respectfully submitted,
W. LEIGHTON COLLINS
Secretary

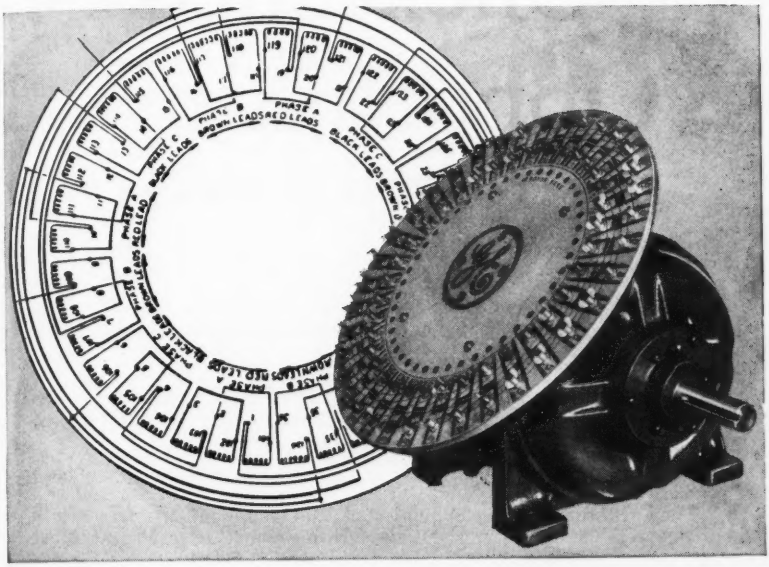
ANNUAL MEETING

June 20-24, 1955

Pennsylvania State University

UNIVERSITY PARK, PENNA.

(formerly State College)



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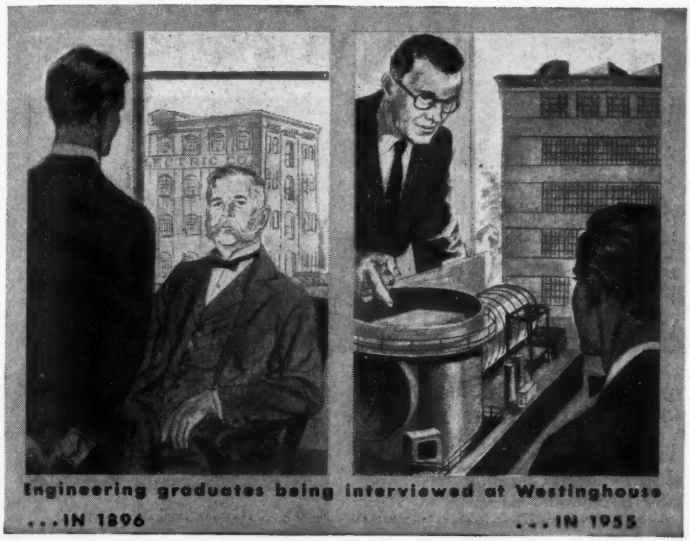

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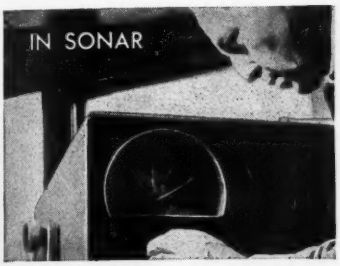

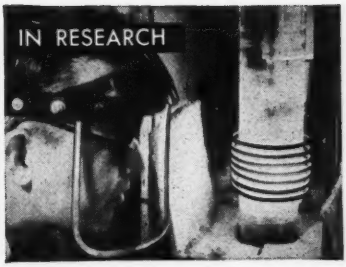

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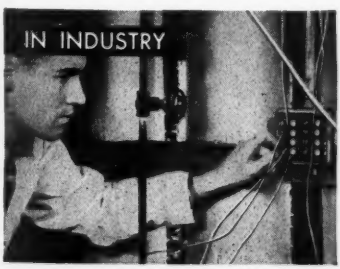

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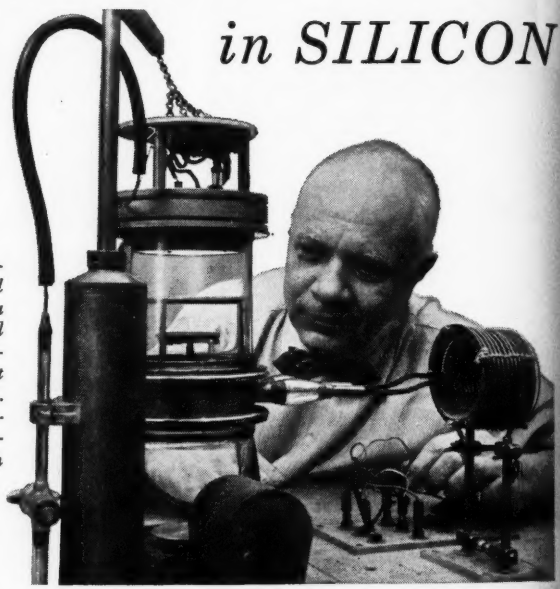

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